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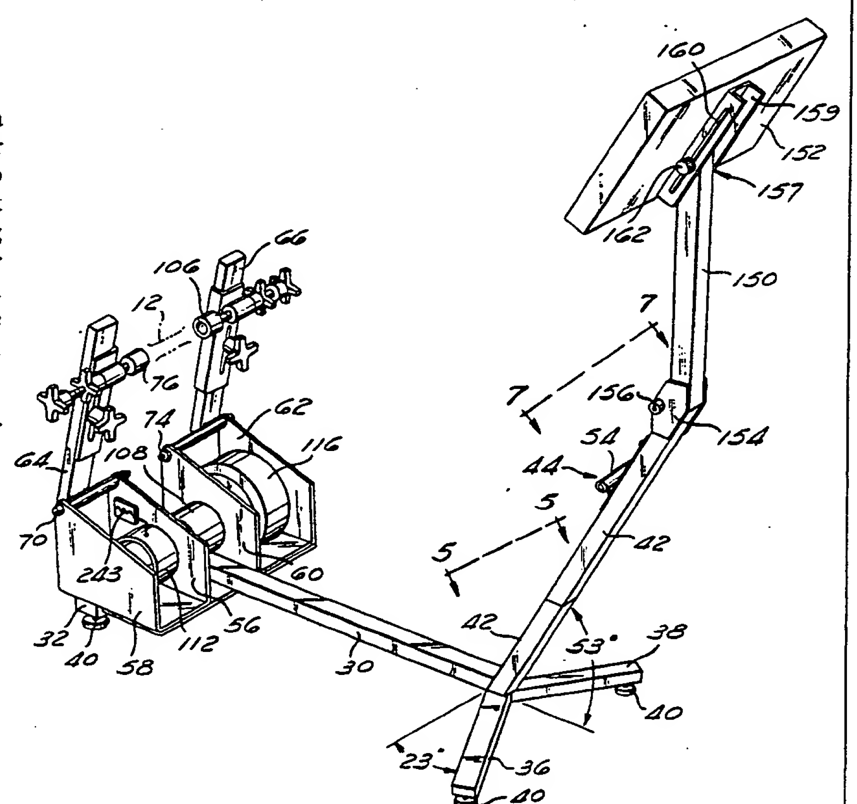
(57) Abstract

An exercising apparatus for supporting a bicycle, a pivotally mounted support member (64, 66) connects the rear axle (12) of the bike to constrain movement of the axle about the pivot point (70) of the support member. A supporting roller (108), cooperates with the support member to support the rear wheel. A flywheel (116) and variable load means (112) are connected to the roller to simulate the inertia and variable load experienced during the riding of a bicycle. When a rider of a bicycle shifts his weight forward the front fork support (42) bends and the rear tire of the bicycle pivots toward the roller to maintain frictional contact between the tire and roller. Frictional losses are determined and the variable load means compensates for the losses, and compensation is made for the inefficiency of the variable load means. The heart rate is monitored and the load is controlled to maintain the heart rate within predetermined limits.



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BICYCLE RACING TRAINING APPARATUS

Background of the Invention

This invention generally relates to a bicycle-type stationary exercise apparatus used with load control devices, display devices, and heart monitoring devices. The invention is particularly directed to an apparatus for use with a multi-speed bicycle, and is especially suited to train for bicycle races.

Field of the Invention

A number of present-day gymnasiums and exercise clubs have stationary bicycle-type apparatus, whereby a person can pedal a simulated bicycle as a form of exercise. Typically, the bicycle pedals are connected to a frictional device or other load in a way such that the amount of resistance can be adjusted by the person riding the bicycle. Typical examples of this type of stationary bicycle are shown in U.S. Patent Nos. 4,358,105 (the "Lifecycle'') and 4,613,129.

Other exercise devices are adapted so that a conventional bicycle can be mounted to an apparatus which supports the bicycle so that the rear wheel of the bicycle can rotate against a frictional load. These types of devices fall into several general categories, the first of which connects both the front axle and the bottom bracket of the bicycle to a frame in order to support the bicycle. The rear wheel drives against a roller which, in turn, is connected to a loading mechanism. One example of such a device is shown in U.S. Patent No. 4,441,705 to Brown, in which the rear wheel drives a flywheel and a variable resistance load.

A second type of apparatus used with a conventional bicycle supports the rear wheel, either on a pair of rollers or by a fixed support at the rear axle. For example, U.S. Patent No. 4,596,386 to Sackl attaches to the rear axle to support the axle at a fixed distance from a pair of rollers. U.S. Patent No. 3,903,613 to Bisberg

supports the front wheel of the bicycle, while the rear wheel rests on a pair of rollers.

Each of the above types of devices has numerous drawbacks for use as an exercise device, and as use for a training device for bicycle racing. The stationary, simulated bicycles, like the "Lifecycle", do not provide a realistic pedal resistance simulating that obtained from riding a real bicycle; they do not adequately simulate inertia, wind resistance, terrain variations, and rolling resistance. Further, this type of stationary bicycle does not realistically simulate the body position or the feel of riding a bicycle, which is not surprising because a standard bicycle frame is not even used.

The devices using a bottom bracket support allow the use of a real bicycle frame, but fail to provide a realistic resistance and ride simulation. This type of equipment usually has one roller contacting the rear wheel.

The devices using a roller or rollers to support the rear wheel have stability and slippage problems. If the roller is behind the rear axle, the roller must be long since the wheel wobbles and moves sideways as it attempts to constantly "fall off" the roller. If the roller is in front of the axle, the wheel stays centered, but does not maintain adequate contact during periods of maximum torque on the rear wheel. In both cases, if a realistic resistance is applied, the rear tire slips on the roller.

For example, during some performance periods, the bicycle rider is not on the saddle, but is leaning over the handlebars and essentially standing on the pedals. As the weight of the rider shifts forward, the force on the rear wheel decreases and the weight on the front wheel increases, causing slipping of the rear wheel. Further, in this position with a bike on a bottom bracket support, the bicycle pivots about the bottom bracket, effectively removing the rear wheel from contact with the supporting roller or rollers. Thus, just when the maximum resistance

is needed to prevent slipping at the rear wheel, the rear wheel is at a minimum friction contact with the resistance rollers and slips.

The rear wheel can be preloaded against the support roller(s), but the preload device duly constrains the rear wheel so as to ruin the realism of the ride, and also destroys the realism of the simulated resistance when the rider is sitting in the saddle or bicycle seat, pedalling at a slower speed. Further, the bottom bracket holds the frame too rigid, destroying the realism of the ride as in real life, the frame flexes on the wheels.

The devices which use a pair of support rollers on the rear wheel not only tend to be bulky, but require complicated resistance mechanisms on both rollers in an attempt to achieve an appropriate resistance to the rear wheel rotation. Further, they do not simulate the feel of a real ride and may require a different balance and training to be able to remain upright while riding if the front wheel is also supported on a roller, as in the patent to Cassini, et al., No. 4,580,983. For example, if the front fork is fixed or supported, with two rollers on the rear wheel, the rear wheel wobbles and moves while the front is stable. In real life, the rear wheel is stable while the front wheel wobbles or moves. The use of two rollers still does not prevent slipping when the rider comes out of the saddle and leans over the handlebars to exert the maximum force on the pedals. The shift in the rider's weight still causes slippage between the rear wheel and the rollers.

There is thus a need for a device which provides a realistic ride on a bicycle and a realistic resistance, especially so that slippage does not occur when the rider is standing on the pedals to obtain maximum power. Further, there is a need to make such a device portable, especially one which can be used with an individual's own bicycle to provide the maximum realism for training

purposes.

Another aspect of this invention is the realistic simulation of the ride and load resistance experienced when riding a bicycle. The load variables can include wind resistance, whether the rider is going uphill or downhill, the inertia of the rider and bicycle, the friction inherent in the bicycle itself, and the frictional resistance between the bicycle tires and the riding surface.

Previous attempts to accurately replicate these various load effects have all had their drawbacks. For example, the effect of wind resistance has been simulated by rotating fan blades which are mechanically coupled to the rotational speed of the bicycle wheel. While the rotating fan blades can provide a force that increases as the square of the rotational speed of the fan blades, these fans are noisy, inaccurate, not readily adjustable, and cannot be adjusted to account for a variation in wind resistance that will occur with riders of different size and weight.

Similarly, prior devices have attempted to simulate the amount of load to be applied by either a mechanical or electronic brake system. A typical mechanical brake involves a friction belt that wraps around a moving surface to cause a frictional drag on that rotating surface depending upon the tension in the belt. These mechanical systems, however, cannot be accurately calibrated, have a slow response time, and are subject to load variations over time as the elements of the mechanical system go out of adjustment and alignment. The mechanical systems thus have poor repeatability, high variations in drag, and are difficult or impossible to accurately calibrate to a given load.

The electronic braking systems have advantages over the mechanical systems, but the accuracy of the simulated ride depends upon several factors, including how accurately the system can be calibrated, and the realism of the

program with which the electronic brake is varied. An example of variations in the simulation accuracy would be the wind resistance. A fan blade may simulate a load that varies with the speed of the bicycle wheel, but it cannot simulate the load resistance that varies with the size and the weight of the rider, or the wind load variation that occurs from riding at the front of a pack, or in the middle of a pack of other bicycle riders. Thus, there is a need for a more realistic simulation of load variability, and especially the wind load variability.

Both electronic and mechanical braking systems are effective only if they are accurately calibrated, and if that calibration is maintained throughout the load simulation. Electronic systems have previously been calibrated by several methods, including the use of strain gauges, which are accurate, but very expensive and cumbersome to implement. Some electronic and mechanical systems will attempt to measure the system power output by the use of a device such as a generator, and then assume a constant system efficiency and friction in order to calibrate the system. This calibration system cannot accurately predict the frictional losses in the system or any variations in the friction or loads exerted on the bicycle and rider. This type of calibration system also has no absolute reference and is therefore difficult to use in predicting performance under variable conditions.

One final method of calibration is to select an absolute reference and measure system variations against that reference. This type of approach requires that the initial reference be accurately determined, that the reference not vary in real life under different load conditions, and that the reference can be used to accurately monitor and calibrate the various aspects of the system performance. One example of this type of system is an electronic brake which assumes that a specific voltage change will result in a known load variation. Several

defects with this specific example are that the voltage and load relationship are difficult to predict and maintain over various temperatures and times, and that there is not a consistently accurate correlation between the voltage applied, and the load that the rider would realistically expect to experience in riding a real bicycle.

There is thus the need for a realistic way to calibrate the exercise system. There is a need for a realistic way to vary the loads in that exercise system so as to more accurately simulate the real life loads experience by a bicycle rider.

Yet another aspect of this invention is the ability to simulate realistic load conditions. United States Patent No. 4,441,705 uses fans attached to a bicycle wheel to simulate wind load, while Patent No. 4,542,897 to Melton shows a simulated competitor traveling at a predetermined speed. However, nothing in the prior art discloses varying the wind force according to the position of a racer with respect to one or more simulated riders. There is thus a need for a device which can simulate the race effect of varying the wind resistance depending on the position of the person exercising on the apparatus, with respect to a simulated rider.

Yet another aspect of this invention deals with the user's heart rate while exercising, which increases as the exercise progresses. To get the maximum benefit from the exercise, the heart rate should be within certain limits for a period of time. If the heart rate is too great, however, it is not productive, and may be damaging to the rider.

Prior devices, such as United States Patent No. 3,767,195 to Delick, provide visual indicators to indicate an upper limit for the heart rate by flashing a visual indicator when the upper limit was reached. The rider determined how much, if at all, to decrease the exercise level in order to lower the heart rate.

There is thus a need for a device which monitors the user's heart rate and adjusts the applied load in order to maintain that heart rate, or to prevent exceeding maximum heart rate limits. Desirably, the device should provide optimum heart rates if the user does not know such information.

Summary of the Invention

An apparatus is provided which supports a rear wheel and tire of a bicycle so that a forward shift in the rider's weight causes the rear tire of the bicycle to maintain frictional contact with a roller in order to prevent slippage. The roller is rotatably mounted about a first axis substantially parallel to a rear axle of a bicycle connected to the apparatus. The rear tire is constrained to move in a predetermined manner toward the roller. Preferably, the rear axle of the bicycle is supported on opposite ends of the axle shaft by axle clamps which are adjustably positioned on a rear axle support member. The support members constrains the rear axle to move along a predefined path which extends generally toward the roller. An arcuate path is preferred.

Preferably, the rear axle support means comprises a pair of members, each pivoted at one end about a pivot axis substantially parallel to the rotational axis of the rear wheel and tire. This pivot axis is preferably on the horizontally opposite side of the rear axle of the bicycle, as is the roller's rotational axis. The rear axle clamps can be adjustably positioned to accommodate different sizes of bicycles.

A variable load means, such as a motor, and preferably an alternator, and an inertial means, such as a flywheel, are connected to the roller and are preferably on a common shaft. The variable load and inertial loads exerted on the roller are transferred, via frictional contact with the rear tire, to the bicycle and its rider to simulate the momentum and load experienced during the actual riding of a

bicycle. Such loads would include wind resistance, terrain variations, rolling resistance, and the inertia of the bike and rider.

While the roller and support member can be used alone to support the bicycle, it is preferred that the front fork of the bicycle is mounted to a front fork support tube by use of a fork mounting bracket. Preferably the front fork support tube is such that it provides a realistic flexibility to simulate a realistic ride. The fork mounting bracket is positionally adjustable to accommodate different sizes of bicycles. The mounting bracket can flex to simulate real life flexing of the fork and front wheel. By repositioning the mounting bracket relative to the front fork, the elevation of the attached bicycle frame can be changed to tilt slightly upward from a level orientation.

Preferably, the front fork support tube is connected to the same structure that supports the roller and rear axle support mount. Thus, a shift in the weight of the rider off of a bicycle seat toward the front fork will cause the front fork support tube to bend and cause the rear axle support mount to rotate the rear bicycle tire toward the roller so as to prevent slippage between the roller and rear tire.

The front fork support tube also supports a display which is in electronic communication with the roller and alternator so that data, such as the bicycle speed, can be displayed for viewing by the rider.

There is thus advantageously provided a means for supporting a bicycle so as to simulate a realistic ride on that bicycle while preventing slippage of the rear wheel of the bicycle during periods of maximum force on the pedals. The realistic ride includes the feel of the load on the rear tire, as well as the flexibility of the bicycle.

The exercise apparatus can be collapsed into a smaller, portable configuration for portability and for storage. The front fork support tube contains hinges which

allow the tube to be folded into an adjacent relationship with the remainder of the apparatus. A releasable hinge adjacent the display unit, and a second releasable hinge located above the fork tube mount bracket, allows the display unit to be folded against the front fork support tube. The hinge at the bottom of the front fork support tube allows that tube, along with the display unit and its support members, to be folded into a position adjacent the roller. The pivot axes, about which the rear axle support members pivot, are positioned so that the rear axle support members can be folded into a position adjacent the roller. Wheels are provided on the end of the frame, adjacent the heavy flywheel and alternator, to allow easy movement of the portable package. There is thus provided a hinging means by which the apparatus can be folded into an adjacent relationship to present a smaller configuration which is much more portable than the operational configuration of the apparatus.

The apparatus is preferably calibrated to accurately produce the intended loads. One way to do this is to determine and compensate for the frictional losses in the apparatus when a bicycle is mounted on the apparatus. The steps for such a calibration sequence comprise: rotating a wheel in an exercising device until the wheel attains at least a first predetermined rotational velocity; allowing the wheel to coast down to a second predetermined rotational velocity during which coasting period the loading device is not exerting loads on the wheel other than inherent frictional loads; sensing and recording the time and rotational velocity at periodic intervals as the wheel coasts down from the first velocity to the second velocity; determining the rotational mass moment of inertia of any components of the exercise device that rotate because the wheel rotates; performing a linear regression analysis on the recorded velocities and times to determine the deceleration of the wheel and rotating components as a

function of velocity; and deriving the frictional load from rotation of the wheel and the rotating components of the exercise device from the formula Frictional torque equals the Mass Inertia times the Angular deceleration. An additional step would comprise computing the power required to overcome the frictional load from the formula: Power equals Mass moment times angular velocity.

The inefficiency of the loading device (which is preferably an alternator) is compensated for by the steps comprising: determining the efficiency of the loading device; determining the power output of the loading device by comparing the efficiency of the loading device with a second loading device for which the power output is known; and adjusting the loading device to account for the frictional losses and the efficiency of the loading device. Preferably, the efficiency is determined by performing a linear regression analysis to determine the power dissipated by the loading device at a predetermined speed, and by performing a linear regression analysis to determine the power which the loading device applies to the wheel.

When the loading device comprises an electrical device which exerts a load on the wheel where the load can be varied by varying the voltage applied to the loading device, the power dissipated is determined by the steps comprising: rotating the wheel until the wheel attains at least a third predetermined rotational velocity; allowing the wheel to decelerate to a fourth predetermined rotational velocity; applying a constant decelerating force from the electrical device in order to further decelerate the wheel as it decelerates from the third to the fourth velocities; sensing and recording the rotational velocity of the wheel and the voltage output by the electrical device at periodic intervals of time as the wheel decelerates from the third velocity to the forth velocity; performing a linear regression analysis on the recorded wheel velocity and the square of the voltage from

the coast down between the third and fourth velocities to determine the deceleration of the wheel and rotating components as a function of velocity; and wherein the power output by the loading device is further determined by the step comprising: performing a linear regression analysis on the velocity and on the deceleration times the velocity from the coast down between the third and fourth velocities in order to obtain linear regression constants for use in determining the power applied.

When the calibration steps are implemented by the above described exercise apparatus, the above apparatus further comprises variable load-applying means communicating with the roller for applying variable loads to the roller to simulate variations in the load encountered during actual riding of a bicycle; and calibration means for determining the friction retarding the wheel from rotating so the variable load-applying means can compensate for the friction. Preferably the calibrating means further comprises means for determining the efficiency of the variable load-applying means so the load-applying means can compensate for the inefficiencies of the load-applying means.

By accounting for the friction in the apparatus, and the inefficiencies of the loading devices, a more accurate load can be applied resulting in a more realistic ride simulation.

Another feature of this invention is a device and method to control the heart rate of a person exercising on the exercise apparatus. The heart rate controlling device takes the form of a decreased heart rate means operating when a person's heart rate is below a predetermined lower limit in order to increase the heart rate. The decreased heart rate means determines whether the loads exerted by the variable load means just increased and if so whether the heart rate has been at an increased rate for a predetermined period of time, with the decreased heart rate

means causing the variable load means to increase the load if the load is below a predetermined maximum value.

An increased heart rate shutdown means operates when a person's heart rate is more than a predetermined amount above the upper limit, to substantially decrease the load exerted by the variable load means. There is also an increased heart rate means that operates when the person's heart rate is above a predetermined limit in order to decrease the heart rate. The increased heart rate means determines whether the load exerted by the variable load means just increased, and if the load has been at an increased level for a predetermined time, the increased heart rate means causes the variable load means to increase the load. The increased heart rate means decreases the load exerted by the variable load means if the load has not just decreased and if the load is not below a predetermined value.

A means for monitoring the heart rate of the person exercising, and communicating that heart rate to the increased and decreased heart rate means, and to the increased heart rate shutdown means is also provided. A display screen communicates information on the loads and heart rate to the person exercising. If the person exercising does not know the appropriate limits to limit the load means, then the person inputs his or her age and sex, and the limits are determined by a computer.

The steps of the method by which the heart rate of the person exercising is controlled comprise: exercising by use of an exercise device so as to increase the heart rate of the person; varying the load which the exercise device exerts on the person to vary the heart rate of the person; sensing the heart rate of the person during the exercise; increasing the load by a predetermined amount when the person's heart rate is below a first predetermined value, with the increasing step comprising the further steps of: determining whether the variable load applied by the

exercise device on the person has just increased, determining whether the variable load has been unchanged for a first predetermined period of time, determining whether the load is below a first predetermined load value, and increasing the variable load by a predetermined amount when the load has not been changed during the first predetermined period of time and when the load is below the first predetermined load value. Additional steps comprise: decreasing the load by a predetermined amount when the person's heart rate is above a second predetermined value, the decreasing step comprising the steps of: determining whether the heart rate is above a third predetermined heart rate value, substantially decreasing the variable load while the heart rate is above the third predetermined load value, determining whether the variable load has just decreased, determining whether the variable load has been unchanged for a second predetermined period of time, determining whether the variable load has reached a second predetermined load value, and decreasing the variable load when the load has not been decreased for the second predetermined period of time and when the variable load has not yet reached the second predetermined load value.

An additional step on this method would be visually displaying messages to the person exercising, regarding either the load exerted by the person in response to the variable load, or to the person's heart rate. The imputing of data on the rider's age and sex, and the calculation of appropriate values or limits on heart rate would be yet another step of this method. Combining the heart controlling method and apparatus with the various variations on the bicycle support provides a realistic ride simulation. As described below, calibrating the friction in the exercise device, and in the load applying device further enhance the accuracy of the control on the load affecting the heart rate. Also as described below, combining the various race simulations provides an

advantageous way to train for races without over stressing the physical abilities of the rider. There is thus advantageously provided a means to adjust the load to maintain the user's heart rate within predefined limits, so as to provide a maximum of exercise and training, while automatically monitoring the user's heart rate to prevent over taxing the user.

There is also provided a method and apparatus for realistically simulating the loads experienced during a bicycle race. The race simulation apparatus comprises a stationary bicycle having a rear wheel that can be pedaled; means for selecting the performance ability of a group of simulated racers and simulating the race performance of the selected group of riders; input means connected to the rear bicycle wheel for determining the performance of a person pedaling the bicycle relative to the performance of the simulated racers; display means for displaying the position of the racer with respect to the simulated racers; and variable load means for exerting a variable load on the rear wheel to simulate the loads experienced during racing; and means for varying the load on the bicycle wheel depending on the position of the racer with respect to the group of racers. Preferably the above devices comprise the apparatus previously described above in greater detail.

Preferably the apparatus causes the variable load means to exert an increased load on the wheel to simulate a variable wind load when the racer leaves the group of simulated racers. Further, the preferred apparatus further comprises means for causing the speed of the group of riders to vary randomly during a simulated race.

To simulate various races of selectable difficulty, there is provided a selection means for selecting a performance level of at least one simulated competitor; load calculation means for determining the load exerted by the load-applying means, based on the selected performance level; load sensing means for sensing the load exerted by a

rider to overcome the load applied by the load-applying means; means for displaying the performance of a rider relative to the simulated competitors; and means for varying the load exerted by the load-applying means depending on the position of a rider relative to the position of the simulated competitors. As a further variation, the display means further comprises means for displaying the elevation of the selected course, the position of a rider on the preselected course, the position of the rider relative to the simulated competitors, and the total elapsed time the instantaneous speed of the rider, distance traveled, heart rate, and cadence.

Preferably the load applying means takes the form of an electrical load-applying device communicating with a roller for applying variable forces to the roller to simulate the variations in load encountered during actual riding of a bicycle when a rear wheel of a bicycle is frictionally engaged with the roller and has a rear axle supported by the support member, the load-applying device also detecting the power exerted by a rider to overcome the applied load.

The various operations are preferably controlled by a computer controlling the load applied by the load-applying means, the computer having an input device by which a person can select a desired level of competition and the corresponding loads which are exerted by the load-applying device, the computer being programmed to determine and display on the visual display unit the performance of at least one simulated rider of the selected competition level, the computer being programmed to determine and display the position of a rider relative to the position of the simulated riders from the power exerted by the rider and simulated riders, the computer varying the load exerted by the load-applying device depending on the relative position of the rider and simulated riders to simulate wind load. The computer varies the performance of the simulated

competitor randomly within the selected level of competition.

The steps in the sequence implemented by the apparatus comprise: applying loads to the rear wheel by an electrical device in order to simulate various riding conditions and situations; applying loads to the rear wheel by a flywheel in order to simulate inertial loads; selecting a race course and the level of difficulty for the competition in the race; determining the loads to be applied to the rear wheel based on the selected level of difficulty for the selected race course; monitoring the performance of a rider pedaling the bicycle with the loads exerted on the rear wheel of the bicycle; displaying the position of the rider relative to at least one simulated rider; and varying the loads on the rider depending on the position of the rider relative to the simulated riders.

Further variations in the sequence comprise randomly varying the performance of the simulated riders during the course of the race; calibrating the electrical device to determine the friction in the exercise device so the electrical device can be adjusted to compensate for the friction loads; determining the efficiency of the electrical device; determining the power output of the electrical device by comparing the efficiency of the electrical device with a second electrical device for which the power output is known; and adjusting the electrical device to account for the frictional losses and the efficiency of the electrical device.

There is thus advantageously provided an apparatus and method not only for simulating the real "feel" of riding a bicycle, but for realistically simulating the loads experienced by riding that bicycle, even accounting for friction and inefficiencies in the apparatus and bicycle. The ability to simulate the environmental loads experienced during races, and to simulate competitors of selectable capability, provides not only a challenge, but a valuable

training tool and method. The ability to account for wind loads as a function of the rider's position within a pack provides further realism. The random variation of pack performance during the simulated race allows a rider to experience various strategies of jockeying for position. There is thus provided not only a more realistic and entertaining exercise device, but a device and method highly suitable for training for competitive races.

Brief Description of the Drawings

The present invention can be more readily understood when reference is made to the accompanying drawings in which:

Fig. 1 is a perspective view of this invention with a bicycle connected to it.

Fig. 2 is a perspective view of this invention with the side covering removed.

Fig. 3 is an exploded perspective of the rear axle clamp, its support, and the motor and flywheel.

Fig. 4 is a perspective view of a rear axle clamp.

Fig. 5 is an exploded perspective of a slidable hinge used on the front fork tube.

Fig. 6 is a perspective view of the assembled hinge shown in Fig. 5.

Fig. 7 is a perspective view of the front fork mounting structure and an adjacent hinge.

Fig. 8 is a perspective view of the invention with its support members folded into adjacent relationship to form a more compact, portable structure.

Fig. 9 is a perspective view of a segment of the invention showing wheels on the structure.

Fig. 10 is a side view of the folded and collapsed structure of Fig. 8.

Fig. 11 is a flow chart of a calibration sequence.

Fig. 12 is a plan view of the display unit as seen from a person exercising on a bicycle placed on the support apparatus shown in Fig.'s 1 - 10.

Fig. 13 is a flow chart of a power calibration sequence.

Fig. 14 is a plan view of a display window of the display unit as shown in Fig. 12.

Fig. 15 is a flow chart of a race simulation mode where wind load is taken into account;

Fig. 16 is a flow chart of a sequence to maintain a rider's heart rate within predetermined limits by varying the load on the exercise apparatus.

Description of the Preferred Embodiment

Referring to Fig. 1, there is shown a portion of a multi-speed bicycle having a frame 10 with a rear axle 12 on which is mounted a rear wheel 14 and a rear tire 16. The frame 10 also contains a bottom bracket 18 to which a crank set and pair of pedals 20 are rotatably mounted. A seat 22, handlebars 24 and a rotatably mounted fork 26, are also connected to the frame 10 in a manner known in the art and not described in detail herein.

Referring to Figs. 1 and 2, a portion of the bicycle is connected to a means for supporting the bike, such as support frame 28. The support frame 28 comprises a bottom member 30 which is approximately 27 inches long, and of a square tubular metal, approximately 1.5 inches per side, with a wall thickness of .109 inches.

At one end of the bottom member 30 are two rear legs 32 and 34 (Fig. 9) which extend in opposite directions generally perpendicular to the longitudinal axis of bottom member 30. Preferably, the legs 32 and 34 are opposite ends of a continuous member. At the opposite end of bottom member 30, there are connected two front legs 36 and 38 which extend in generally opposing directions from the bottom member 30. The front legs 36 and 38 extend at an angle of approximately 67 degrees from the longitudinal axis of the bottom member 30 so as to angle away from the rear legs 32 and 34. The same angle, measured from the perpendicular, is 23 degrees. The legs 32 and 34 are all

of tubular metal construction having a generally rectangular cross-section approximately .75 inch x 1.5 inches, with a wall thickness of about .120 inches. The legs 36 and 38 are also tubular of construction having a rectangular cross section of about 1 inch x 2 inches, and a wall thickness of .120 inches.

The bottom member 30 and legs 32, 34, 36 and 38 lie generally in a plane so as to provide a stable support for the bike frame 10 and rider. Support feet 40 are located at the outermost ends of the legs 32-38 and are intended to rest against a floor.

A means for supporting and mounting the front fork 26 of a bicycle is provided which simulates the movement, and flexibility of a front wheel of a bicycle. Thus, fork tube 42 is connected to the juncture of bottom member 30 and front legs 36 and 38. The fork tube 42 extends out of the plane of the legs 32-38 at an angle of approximately 53 degrees from that plane, and in a direction away from the rear legs 32 and 34. The fork tube 42 also extends along a plane passing through the longitudinal axis of the bottom member 30 and oriented substantially perpendicular to the plane formed by the legs 32-38. The fork tube 42 is of a tubular metal construction, using 1.5-inch square tubing with a wall thickness of .109 inch.

Referring to Figs. 2 and 7, a fork mount 44 is connected to the side of the fork tube 42 facing the rear legs 32-34. Referring to Fig. 7, the fork mount 44 comprises a generally rectangular strip of metal 1.25 inches wide by 6.25 inches long and .135 inch thick. Two elongated slots 46 and 48 are located along the longitudinal axis of fork mount 44. Preferably, the slots 46 and 48 are approximately .34 inch wide by 1.85 inches long, and begin about .33 inch from the ends of fork mount 44.

Removable fasteners 50 and 52 extend through the slots 46 and 48 into corresponding apertures (not shown) in the

fork tube 42 in order to connect the fork mount 44 to the fork tube 42. Preferably, the fasteners 50 and 52 take the form of threaded bolts. By loosening the fasteners 50 and 52, the slots 46 and 48 allow the fork mount 44 to be slid along the length of the slots 46 and 48, thereby permitting repositioning of the fork mount 44 relative to the length of the fork tube 42. The fasteners 50 and 52 can be removed so the fork mount 44 can be rotated 180 degrees in the plane in which it is mounted, and then re-secured. The fasteners 50 and 52 allow the fork mount 44 to flex, and help simulate a realistic movement of a bicycle attached to the frame 28 via the fork mount 44.

A fork mounting tube 54 (see also Figs. 1 and 2) is connected to the fork mount 44. The fork mounting tube 54 comprises a metal tube approximately 3.5 inches long, with an outer diameter of about .75 inch, and an inner diameter of about .38 inch. The interior ends of the fork mounting tube 54 can be threaded. The fork mounting tube 54 is located with its longitudinal axis perpendicular to the longitudinal axis of the fork mount 44 and the slots 46 and 48. The fork mounting tube 54 is not located at the center of fork mount 44, but is offset approximately 1/4-inch so that it is closer to the end of slot 48 than it is to the end of slot 46.

The fork mount 44 provides an adjustable attachment means for connecting the front fork of a bike to the fork tube 42. The adjustable feature is used to accommodate different sizes of bicycle frames and, as described later, to alter the elevation of the bike frame 10 by repositioning the fork mount 44 on the fork tube 42.

Referring to Figs. 2 and 3, connected to the rear leg 32 is an inner support plate 56 and an outer support plate 58. The support plates 56 and 58 are substantially parallel plates located in planes substantially parallel to a plane passing through the longitudinal axis of bottom member 30, but substantially perpendicular to the plane in

which the legs 32, 34, 36 and 38 are located. The inner support plate 56 is closer to the bottom member 30 than is outer plate 58. The support plates 56 and 58 can be made out of .134 inch thick steel.

An inner support plate 60, which generally corresponds to inner support plate 56, is connected in an analogous manner and orientation to rear leg 34. Similarly, an outer support plate 62, which corresponds to outer support plate 58, is connected in an analogous manner and orientation to the rear leg 34.

When a rear wheel 14 and rear tire 16 (Fig. 1) are connected to the apparatus, the rear tire 16 is constrained to move in a predetermined manner. Preferably, a rear axle support member constrains the rear axle 12 of a bicycle to move along a predetermined path. While the support member could be a U-shaped member, preferably, the support member is a pair of axle tubes 64 and 66. The first axle tube 64 is rotatably mounted between the support plates 56 and 58, and a second axle tube 66 is rotatably mounted between the support plates 60 and 62. The first and second axle tubes 64 and 66 are constructed and connected in an analogous manner, so only the first axle tube 64 will be described in detail.

Referring to Fig. 3, the first axle tube 64 is preferably a stiff or rigid member, which does not flex to any great extent, and can comprise a tubular metal bar having a rectangular cross-section approximately .75 inch thick and 1.5 inches wide, 12.5 inches long and about .12 inch thick. A rotatable mount 68 is connected at one end of first axle tube 64 to one of the 1.5-inch wide sides of axle tube 64. The rotatable mount 68 is shown as a cylindrical tube with an outside diameter of about 1 inch and an inside diameter of about .52 inch, and a length of about 4.7 inches which corresponds to the spacing between the support plates 56 and 58. The longitudinal axis of the rotatable mount 68 is perpendicular to the longitudinal

axis of the first axle tube 64.

The first axle tube 64 is mounted so that it can pivot in a plane substantially perpendicular to the plane in which the legs 32-38 are located, substantially parallel to the plane of the bottom member 30. This pivot axis is substantially parallel to the rotational axis of the rear wheel 14 and tire 16 connected to the axle tubes 64 and 66.

Pivoting action is achieved by passing a bolt 70 through a hole 72 in the outer support plate 58, through the inside of the rotatable mount 68, and through a corresponding hole (not shown) in inner support plate 56. A fastener 74, such as a threaded nut, is welded to the side of inner support plate 56 so that a threaded end on bolt 70 can be secured by the fastener 74 to prevent inadvertent removal of the bolt 70. The longitudinal axis of the bolt 70 is substantially parallel to the longitudinal axes of rear legs 32 and 34. The bolt 70 thus supports the first axle tube 64 and constrains the axle tube 64 to pivot about the longitudinal axis of bolt 70.

As previously stated, a second axle tube 66 is pivotally mounted and constrained to pivot about a bolt 70 in a similar manner as the first axle tube 64 with such bolts coaxially aligned. The axle tubes 64 and 66 are located adjacent the respective outer support plates 58 and 62. The inner sides of axle tubes 64 and 66 are about 11 inches apart. The first and second axle tubes 64 and 66 thus form movable support means which constrain the rear wheel 14 and tire 16 to move along a predetermined path.

As shown in Figs. 2 and 3, at the end of axle tubes 64 and 66 opposite the pivotally constrained end are axle clamps 76 and 106 which are connected to the axle tubes 64 and 66 by an axle clamp bracket 78. Referring to Fig. 4, the axle clamp 76 comprises a metal cylinder with a conical depression 77 in one end. A pair of opposing rectangular slots 79 extend partway down opposing sides of the axle clamp 76. In use, a conical-shaped nut or end of the

bicycle's rear axle 12 is seated in the conical cavity 77. The slots 79 accommodate D-rings that are used on the quick release skewers used with several bicycle models.

Referring to Fig. 3, the axle clamp bracket 78 comprises a repositionable support plate 80 comprised of a strip of metal having an L-shaped cross-section .75 inch on the short side, 1.5 inches on the long side, 6 inches long and .120 inches thick. An elongated slot 82 runs along the longitudinal axis of the plate 80 for a length of about 3 inches.

A bolt 84 has a threaded portion which extends through the slot 82 and through a hole (not shown) in axle tube 64. A fastener such as a threaded nut 86 can be removably connected with the threaded end of bolt 84 in order to releasably clamp the plate 80 to the axle tube 64. The plate 80 can be repositioned along the length of the axle tube 64 by loosening the bolt 84 and sliding the plate 80 along the length of slot 82, and then reclamping the bolt 84 and nut 86.

At the end of the plate 80, adjacent the unconstrained end of axle tube 64, is a clamp tube 88. The clamp tube 88 is a cylindrical tube having an outer diameter of about 7/8 inch, a threaded inside diameter of about 1/2 inch, and a length of about 1.5 inches. The tube 88 has its longitudinal axis substantially perpendicular to the longitudinal axis of axle tube 64 and substantially parallel to the longitudinal axis of bolt 70. A threaded shaft 90 threadingly engages the interior threads of tube 88. The axle clamp 76 is fastened at one end of shaft 90, with a knob 92 being fixed at the opposing end of shaft 90. By rotating the knob 92, the shaft 90 can be rotated so as to reposition the axle clamp 76.

A locking knob 93 is located intermediate to the knob 92 and the tube 88. The locking knob 93 is a knob having a threaded hole through the center, so the knob can be screwed along the length of threaded shaft 90. When the

axle clamp 76 is correctly positioned, the locking knob 93 is screwed against the end of tube 88 to provide a frictional lock, preventing axial movement of shaft 90 and axle clamp 76.

A second axle clamp 106 coaxially aligned with clamp 76 (Figs. 3 and 4) is connected to the unconstrained end of the second axle tube 66 in the same manner as axle clamp 76 is connected to the first axle tube 64. Thus, the details of the second axle clamp 106 and its supporting bracket will not be repeated, other than to note that one axle clamp is slightly longer, with a deeper slot 79, in order to accommodate a variety of designs for axles 12 as used on diverse bicycles.

Referring to Figs. 2 and 3, a rotatable means helps support the rear wheel 14 of a bicycle connected to the apparatus of this invention. A roller 108 is rotatably supported between the inner support plates 56 and 60. Preferably, the roller 108 is a cylindrical roller with a width of about 2.6 inches and an outer diameter of 2.5 inches, made of aluminum. The roller 108 is rotatably mounted so that its longitudinal axis is substantially parallel with the longitudinal axis of bolt 70 and the pivot axis of first and second axle tubes 76 and 106, and with the rotational axis of a rear wheel 14 connected to the apparatus.

Referring to Fig. 1, preferably the support frame 28 connects to, and supports, the bike frame 10 at three locations. As shown best in Fig. 7, the fork 26 of bike frame 10 can be removably connected to the fork mount 44 by use of a quick-release skewer 110. The quick-release skewer 110 is commonly used on bicycles having a readily removable front wheel, and thus is known in the art and will not be described in detail. The ends of fork 26 fit over the fork mounting tube 54. The quick-release skewer 110 is inserted through the fork 26 and the fork mounting tube 54, and then locked to secure the fork 26 to the fork

mount 44. Basically, the fork mount 44 is connected just as if it were the front wheel of a bike.

Referring to Fig. 1, the rear axle 12 of the bike frame 10 is supported by the first and second axle clamps 76 and 106. The conical apertures 77 (Fig. 4) in the axle clamps 76 and 106 fit over the opposite ends of the rear axle 12 so as to support axle 12 and bike frame 10. The rear axle 12 is constrained to move along an arcuate path about the rotational axes of first and second axle tubes 64 and 66, with the path being generally toward roller 108.

The tire 16 rests against the roller 108. Preferably, when viewed in a horizontal plane, the roller 108 is in front of the rear axle 12. The rear axle 12 is shown as being horizontally in front of the rotational axis about which the axle tubes 64 and 66 rotate. Thus, the axle 12 (about which rear wheel 14 rotates) is positioned, relative to a horizontal plane, between the roller 108 and the rotational axis about which axle tubes 64 and 66 rotate. Alternately phrased, if substantially parallel, vertical planes are passed through the rear axle 12, rotational axis of roller 108, and the rotational axes of axle tubes 64 and 66, then the vertical plane containing the rear axle 12 lies between the planes containing the rotational axes of roller 108 and axle tubes 64 and 66. Phases yet another way, a substantially vertical plane through the rear axle 12, would result in the pivot axis of the rear axle tubes 64 and 66 and the roller 108, being located on opposite sides of that vertical plane.

It is believed preferable that the angle of the rear axle tubes 64 and 66, with respect to the vertical, be between 5-30 degrees. From this position, the tubes 64 and 66 will rotate from 1-4 degrees further during operation, depending on rider weight and strength, tire pressure, and the specific bike frame 10. When the bike frame 10 is that of a Schwinn Paramount having a 54 cm frame, and a 99 cm wheelbase, with 700C wheels, the angle is about 26.5

degrees, with the rear axle 12 being about 10.5 inches from the pivot points of axle tubes 64 and 66, and with the rear axle 12 being almost vertically above the rotational axis of roller 108. These dimensions are at the extreme end of dimensions for a short wheelbase racing bicycle.

If the axle 12 is positioned vertically above, or in front of (i.e. toward the handlebars 24) the roller 108, the invention will still function, but as the axle 12 is moved in front of the roller 108, then the performance is increasingly degraded, but it can function. If the rear axle 12 is positioned vertically above, or behind the pivot axis of bolts 70, the rear tire 16 will not be constrained to move into contact with the roller 108 and the apparatus will not satisfactorily function. The objective is to cause the rear tire 16 to move into contact with the roller 108 when the torque on the tire 16 increases, as when the rider leaves the saddle 22 and leans over the handlebars 26 to exert increased force on the pedals 20.

Preferably, the rotational axis of roller 108 is about 4.6 inches (horizontally) from the rotational axis of axle tubes 64 and 66, and about 5.1 inches (vertically) from the rotational axis of axle tubes 64 and 66. The fork mount 44, the axle clamps 76 and 106 (Fig. 2), and the roller 108 provide a three-point support for the bike frame 10 when the frame 10 is coupled to the support apparatus. As a rider pedals the bike via pedals 20, the rear wheel 14 and tire 16 frictionally engage the roller 108, causing roller 108 to rotate.

It is believed possible, although not preferred, to have only the axle clamps 76 and 106 support the bike frame 10, in which case the front fork tube 52 would be eliminated, and the bottom member 30 shortened, so a standard front wheel of a bicycle could be used to support the front fork 26. It is also believed possible, but not preferred, to support the front fork tube 42 separately

from the remainder of the frame 28, and to adjust the flexibility of the fork tube 42 to simulate the stiffness, and to allow the movement, of a normal front wheel of a bicycle.

Referring to Figs. 2 and 3, a variable load device, such as an electromagnetic apparatus like an alternator 112, powered by 110V AC, is connected to the roller 108. The alternator 112 is connected to the inside support plate 56 and is located between support plates 56 and 58. An alternator shaft 114 (Fig. 3) extends through a hole in the inner support plate 56 (Fig. 2). One end of the alternator shaft 114 (Fig. 3) is connected to the alternator 112, with the opposing end being connected to the roller 108, preferably by shrink-fitting the roller 108 onto the end of the alternator shaft 114.

By applying a variable amount of electrical power to the alternator 112, a variable and controllable amount of resistance can be applied to the roller 108, and thus to the tire 16 and the pedals 20 (Fig. 1). This variable load resistance can be used to simulate the resistance experienced by pedalling on different grades, downhill, flat or uphill. The load can simulate rolling resistance, wind resistance, terrain variations, and if properly programmed, can even simulate the inertia of the bicycle and rider. Thus, the alternator 112 communicates with the roller 108 to simulate a realistic bicycle ride.

Preferably, the inertia is simulated by inertia means, such as a flywheel 116, which is rotatably mounted between the support plates 60 and 62 (Fig. 2). The rotational axis of flywheel 116 coincides with the rotational axis of roller 108 and alternator 112. A specific flywheel could be designed for a given weight of a bicycle and rider, and a maximum speed. Space, safety and weight constraints must also be considered, however. A flywheel 116 found suitable for use is designed to rotate at a maximum speed of about 5000 r.p.m., for an equivalent bike speed of 40 miles per

hour for a 27 inch bicycle wheel. Such a flywheel weighs about 22 pounds, and when made of cast iron, can take the form of a rimmed circular disc 2 inches wide and 8 inches in diameter. The inertia of such a usable flywheel has been calculated to be 0.05648 $N*m*sec^2$.

The flywheel 116 communicates with roller 108 so rotation of the roller 108 rotates the flywheel 116. As shown, the flywheel 116 is mounted on a shaft 118 which extends through a hole in the inner support plate 60 to connect to the roller 108. Preferably, the roller 108 is shrink-fit onto one end of the flywheel shaft 118. Thus, the flywheel 116, roller 108 and alternator 112 are essentially on a common rotational shaft. The inertia means, such as flywheel 116, simulates the inertia of a moving bicycle and rider.

Referring to Figs 1 and 2, the fork tube 42 is about 21.5 inches long, and contains a hinged joint 124 which is best shown with reference to Figs. 5 and 6. At a point approximately 7.5 inches above the plane of the legs 32-38 (Fig. 1), the fork tube 42 is cut at an angle such that there is a first end 126 and second end 128 which can be releasably placed in an abutting configuration. On the inside of fork tube 42 adjacent the first end 126, there is inserted a smaller, slidable tubular section 130 which is configured to just fit inside of the first end 126. On opposing sides of slidable tubular section 130 are located longitudinal slots 132. A fastener such as bolt 134 extends through opposing sides of fork tube 42 and through the slots 132 so as to captivate the slidable tubular section 130. Thus, the slidable tubular section 130 can be moved along the longitudinal axis of the fork tube 42 until the bolt 134 bottoms out against the ends of the slots 132.

A rotatable hinge 135 rotatably connects slidable tubular section 130, with a correspondingly sized tubular section 136. The tubular section 136 fits inside of, and is securely fastened to, the second end 128 of fork tube

42.

In operation, the tubular sections 130 and 136 fit on the inside of fork tube 42 and provide a structurally strong joint when the ends 126 and 128 are abutting. The sections 130 and 136 allow the first and second ends 126 and 128 to be separated by a force exerted along the longitudinal axis of fork tube 42. When the first and second ends 126 and 128 are separated, the hinge 135 allows the portion of the fork tube 42 containing the end 128 to be folded so as to collapse the support frame 28 into a more compact configuration (Figs. 8,10).

In order to ensure the integrity of the hinged joint 124 in the uncollapsed position, and to prevent inadvertent separation of the hinged joint 124, releasable fasteners 138 (Fig. 5) extend through the side walls of fork tube 42 and releasably fasten the slidable tubular section 130 into secure position. The fasteners 138 each comprise a threaded portion 140 extending from a knob 142. Each threaded portion 140 extends through an associated threaded aperture 144 in fork tube 42 so that the end of the threaded portion comes into contact with and binds against the slidable tubular section 130 so as to prevent movement of such sections within tube 42. The apertures 144 preferably are located in the corner of the fork tube 42.

The hinged joint 124, and the rotation of the axle tubes 64 and 66 (Figs. 8,10), thus provide collapsible joints by which a stable operational structure can be formed, but which can be collapsed or reconfigured to a configuration more suitable for storage or portability.

Referring to Fig. 1, a side cover 120 has one end connected to the support plates 56 (Fig. 2) and 58 with the opposing end connected to the front leg 36. A corresponding side plate 122 is connected between support plates 60 and 62 (Fig. 2), and front leg 38. The side covers 120 and 122 cover the flywheel 116 and alternator 112 (Fig. 2), and provide some stiffness and stability to

the support frame 28 as well. Because the support plates 56-62 (Fig. 2) are higher than the front legs 36 and 38, the side covers 120 and 122 slant downward at an angle. The side covers 120 and 122 must be sufficiently low so that a rider's heel will not hit the side plates when pedalling. In a similar manner, the axle tubes 64 and 66 must not be so long that they will be hit by the heel of a rider when pedalling.

The side plates 120 and 122 are removable (see Fig. 2) and comprise generally C-shaped structures preferably made out of sheet metal having a thickness of about .060 inches. The sides of the side plates 120 fit over the sides of the support plates 56 and 58 (Fig. 2), and the sides of the side plate 122 fit over the sides of the support plates 60 and 62 (Fig. 2). The sides plates 120 and 122 are spaced apart so that the bottom member 30 is visible between the side plates 120 and 122.

Referring to Figs. 1 and 2, a display tube 150 is connected to the upper end of fork tube 42. A display 152 is in turn connected to the outer end of display tube 150. The display tube 150 is of the same general construction as fork tube 42, and is rotatably joined to fork tube 42 by rotatable joint 154. The joint 154 comprises a hinged member which uses one or more frictionally releasable devices to hold the joint stable when desired, or to release the joint to allow a rotation when desired. The releasable frictional device is shown as comprising a hinged joint, having a side through which a threaded fastener 156 extends to releasably lock the joint 154 by loosening or tightening the fastener 156, the friction in the joint 154 is increased or decreased, so as to lock the joint 154 into position or to allow it to rotate.

The end of display tube 150 is connected to display 152 by means of a repositionable and tiltable joint 157. A channel bracket 159, having a C-shaped cross section is fastened to the back side of the display 152, with the free

legs of the C-section extending outward from the display 152. Each of the free legs of channel bracket 159 has a slot 160, running along the length of the bracket 150. The display tube 150 fits within the channel bracket 159. A releasable fastener 162 has a shaft (not shown) that passes through slots 160 and through a hole (not shown) adjacent the outer end of display tube 150, and connects to a threaded knob (not shown). The fastener 162 and threaded knob cooperate to frictionally lock the end of the display tube 150 to the bracket 159, and thus to the display 152. The connection is releasable by loosening the fastener 162.

The slots 162 allow the display 152 to be positioned relative to the end of the display tube 150, and effectively provide a means for adjusting the height of the display 152. The display 152 can also be rotated about a loosened fastener 162 to adjust the angular orientation of display 152, and tightening the fastener 162 locks the display into position. There is thus provided a joint 157 that allows repositioning and tilting of the display 152.

The display 152 is in electrical communication with the alternator 112 so that various loads can be controlled from, and displayed by, the display 152. The electrical communication mean can comprise wires, which are known in the art and not described in detail, or shown herein. Thus, for example, a rider can input the resistance which is desired to be exerted by the alternator 112, and can monitor the speed at which the bike is being pedalled against that predetermined resistance.

Referring to Fig. 1, the operation of the invention will now be described. A person can take his or her own personal bicycle, remove the front wheel and mount it to the support frame 28. Many modern racing bikes have removable front wheels which facilitate this installation. The fork 26 of the bike frame 10 is attached to the fork mount 44 by use of a quick-release skewer 110. To accommodate for different sizes of bike frames 10, the fork

mount 44 can be releasably positioned by loosening fasteners 50 and 52 (Fig. 7), repositioning the fork mounting tube 54 and then refastening fasteners 50 and 52.

Referring to Fig. 7, as previously mentioned, the fork mounting tube 54 is asymmetrically located between the ends of the slots 46 and 48. By slidably positioning the fork mount 44, relative to the fork tube 42, it is possible to adjust the vertical elevation of the bike frame 10. Many riders find a slight uphill elevation to be more comfortable when riding a stationary bicycle.

Preferably the fasteners 50 and 52 are positioned at, and rest against the upper ends of the slots 46 and 48. If so positioned, the mount 44 bears against the fastener 50 and 52.

Since the mounting tube 54 is offset relative to the ends of slots 46 and 48, the mounting plate 44 can be rotated 180 degrees in plane to change the elevation of the mounting tube 54 (and the bike 10), while still allowing the fasteners 50 and 52 to bear against the ends of the slots 46 and 48.

Referring to Figs. 1 and 3, the tire 16 is placed on the roller 108. The first and second axle tubes 64 are then rotated so the first and second axle clamps 76 and 106 can engage opposite ends of rear axle 12. Turning knobs 92 (Fig. 3) allows the axle clamps 76 and 106 (Fig. 3) to be adjusted along the length of rear axle 12 so the ends of axle 12 can seat in the conical apertures 77. The threaded shaft 90 (Fig. 3) therefore provides an adjustable means for accommodating different axle lengths for positioning of the bicycle frame 10 between the first and second axle tubes 64 and 66. The ability of the first and second axle tubes 64 and 66 to rotate combine with the ability to reposition the axle clamp bracket 78 (Fig. 3) to accommodate a wide range of bike sizes.

Referring to Fig. 1, in operation, the mounting of the fork 26 to the fork mount 44 provides a flexible mount that

reduces stresses and fatigue failure problems with the fork 26. The flexibility is provided by the fact that the fork mount 44 can effectively pivot or flexibly rock about a line passing through the fasteners 50 and 52 (Fig. 7), even when those fasteners are tightly secured. The fork mount 44 and the fasteners 50 and 52 bend to allow this flexibility. The flexibility simulates the lateral flexibility of a front wheel of a bicycle to further simulate a realistic ride.

A rider can reposition the fork mount 44 to provide for a level orientation of bike frame 10, or a slightly elevated orientation as previously described. When the rider sits on the seat 22 and exerts force on the pedals 20, the weight of the bicycle and rider force the tire 16 against the roller 108 to provide a frictional drive of the roller 108. The flywheel 116 (Fig. 2) simulates the inertia of the rider and bicycle, while the variable resistance exerted by alternator 112 (Fig. 2) can be used to simulate a ride on a level surface, a downgrade, an uphill grade or any combination of variable grades.

In use, however, the rider does not always stay seated in the seat or saddle 22, but at times of increased power, rises off of the saddle, leans over the handlebars 24 and exerts all of the rider's weight on the pedals 20. Thus, while more of the rider's weight is on the rear wheel when the rider is seated in the saddle 22, the rider's weight is shifted towards the front wheel when the rider rises out of the seat 22 and exerts increased force and weight on the pedals 20.

As the weight of the rider shifts toward the fork 26, the frame 28 operates to maintain, and can actually increase the friction between the tire 16 and the roller 108 in order to prevent slippage. The first and second axle tubes 64 and 66 constrain the rear axle 12 to move along a predefined, arcuate path such that a shift in the weight of the rider toward the fork 26 causes the axle 12,

and thus the tire 16, to move toward to the roller 108.

It is also believed that the relative stiffness between the bike frame 10 with respect to the frame 28 is such that a movement of the rider toward the fork 26 causes the fork tube 42 to bend or flex forward and downward and, since the bike frame 10 is connected to the fork tube 42, the bike frame 10 causes the constrained axle 12 to rotate toward the roller 108. It is believed preferable that the stiffness of the bike frame 10, including the fork 26, be greater than the stiffness of the support frame 30, which includes fork tube 42, and the axle tubes 64 and 66.

While the exact theoretical basis may not be precisely known, the practical effect is apparent. With the rider seated in the seat 22, the roller 108 and support axles 64 and 66 support the weight that is normally on the rear so there is no excessive friction between the roller 108 and the rear tire 16. As the weight of the rider shifts forward from the seat 22 toward the fork 26, the tire 16 does not slip against the roller 108. The fork tube 42 and constrained rear axle 12 move in unison albeit perhaps in different amounts, with the amount of motion varying with the amount of force exerted on the pedals 20, and the position of the rider relative to the front fork 26. Further, a rider using toe clips and straps on the pedals 20, appears to exert a forward force on the pedals 20 which also causes the fork tube 42 and constrained rear axle 12, to move in unison.

Such was not the case with prior art devices using single or double support rollers. For example, many prior devices used a support that connected to the bottom bracket 18 (Fig. 1). As the weight of the rider shifted forward, the bike pivoted about the support connected to the bottom bracket 18, and the tire 16 moved out of contact with the prior art roller(s). Further, the mere shift in the rider's weight decreased the force on the rear wheel, and thus decreased the friction against the rollers. Thus, the

shift of the weight of the rider effectively decreased the friction between the tire and the roller, causing the roller to slip just when the maximum amount of power was being transferred to the tire.

There is thus advantageously provided a means of increasing the friction between the tire 16 and the roller 108 during periods when large amounts of power are being applied to the pedals 20. There is thus also advantageously provided a means of using the location of the weight of the rider to prevent slippage between the tire 16 and the roller 108. There is also provided a means of using the flexibility of the frame 28 to prevent slippage and increase the friction between the tire 16 and roller 108.

Referring to Figs. 8 and 10, a further advantage of the present invention is that collapsible means are provided so the apparatus can be folded into a compact package to make it readily portable. As previously described, the first and second axle tubes are rotatable about the axis running along the length of bolt 70 (Fig. 3). By correctly positioning the rotational joint, the first and second axle tubes 64 and 66 can be folded into a more compact shape. Preferably, they can be folded adjacent the side covers 120 and 122.

The joints 124, 154 and 157 allow the display 152 to be folded adjacent the side covers 120 and 122. The fork tube 42 and the display tube 150 can fit into the space between the side covers 120 and 122. There is thus provided collapsible means which allow the apparatus to be folded into a more compact, portable configuration than the operational configuration of the apparatus.

Referring to Fig. 2, the heaviest portion of the invention is located at the support plates 56, 58, 60 and 62, which support the flywheel 116 and the alternator 112. Referring to Fig. 9, to increase the ease of portability, a pair of rotatable wheels 170 are mounted at the juncture of

the rear legs 32 and 34, opposite the joinder of the bottom member 30. When the invention is lifted so as to rotate about a line passing through the rear legs 32 and 34, the wheels 170 come in contact with the ground or floor so that the invention can be rolled without dragging the foot pads 40. The wheels 170 are not able to roll when the apparatus is in its operational position as shown in Figs. 1 and 2.

Referring to Figs. 8-10, preferably, the back surface of the covers 120 and 122 and the support plates 56-62 (Fig. 2) are flat so that the invention can maintain a stable standing position on its end, in a vertical orientation as illustrated in Figs. 9 and 10.

As previously mentioned regarding Fig. 2, a variable load device such as the alternator 112 is connected so as to rotate in conjunction with the roller 108. As the armature of the alternator 108 rotates, current variations occur which can be used to indicate the rotational speed of the roller 108. The speed can be calculated by measuring the time between pulses from a diode on the alternator. There are six diode pulses for one revolution of the 2.5 inch diameter roller 108. The pulse data can be used to calculate both speed, and distance traveled. The alternator 112 is in electronic communication with the display unit 152 by means such as wires which are known in the art, and not described in detail herein. In practice, the alternator 112 provides two signals to the display unit 112, one for speed, and one for resistor voltage through an external power resistor 243.

The resistor voltage communicates with an analog to digital (A/D) converter in the display 152. The A/D converter is known in the art and is not described in detail herein. The A/D converter assigns a maximum value of 255 to the voltage, which corresponds to a voltage of 25 volts. A resolution of about 0.1 volts in the A/D converter has been found suitable.

Referring to Fig. 11, the display unit 152 contains a

computer 200 which monitors and/or calculates the rotational speed of the alternator 112 and the roller 108. The rotational speed of the roller 108 is related to the distance travelled, and the speed of the bicycle, which can be calculated by the computer 200. The computer 200 also controls the voltage to the alternator 112 by means of a digital to analog (DAC) converter, which adjusts the field current in the alternator 112.

The computer 200 also works in conjunction with a timer 202 which monitors various functions of the computer at predetermined intervals. The timer 202 works in conjunction with the computer 200 to calculate the absolute amount of friction in the exercising apparatus, and in the bicycle mounted on the exercise apparatus.

The flow chart of Fig. 11, taken in conjunction with Figs. 1 and 12, describes a calibration sequence in which the rider sits on the saddle 22 (Fig. 1) and presses a start button 204 on the display 152 (Fig. 12) in order to initiate the calibration sequence. Upon initiation, block 206 (Fig. 11) instructs the system to warm up, which is preferably achieved by applying full field current to the alternator 112 for about 30 minutes, and then riding the bicycle for a few minutes to disperse the grease in the bearings. The warmup reduces the temperature effects on the system accuracy.

Block 208 initializes the digital to analog converter (DAC) to zero, which causes the alternator 112 (Fig. 2) to place no additional resistance load (other than inherent frictional loads) on the roller 108 (FIG. 2) or tire 16. Block 210 commands the display unit 152 (Figs. 1 and 12) to display an instruction visible by the user to pedal the bicycle to at least 25 mph. This instruction appears in the display window 212 of display unit 152 (Fig. 12). When the bicycle speed is above 25 mph, an audio signal sounds to indicate that the rider can stop peddling and remain seated on the saddle 22 (Fig. 1). The display window 212

also informs the rider to stop peddling after the audio signal sounds.

Block 214 (Fig. 11) starts the coast down calculation when the speed of the wheel 16 (Fig. 1) reaches a predetermined value, 23 mph in this case. Block 216 reads the speed of the wheel 16 (Fig. 1) while block 218 stores that speed in random access storage (RAM). Decision block 220 compares the speed from block 216 with a predetermined value, preferably 5 mph. If the speed is greater than 5 mph, the decision block returns the sequence to block 216 for re-reading the speed. The speed is checked at periodic intervals, preferably every 0.12 seconds. When the speed reaches 5 mph, the block 222 computes the deceleration of the bicycle dV/dT, where dV is the change in velocity, and dT is the change in time over which the velocity change occurred.

The deceleration is computed by a linear regression, with each consecutive 20 speed readings being averaged to get a series of velocities, v_1, v_2, v_3, ... v_n for each velocity v between 5 and 23 mph. A linear regression is then performed on the points:

$$x_i = (v_i + v_{i+1}) / 2$$

$$y_i = (v_i - v_{i+1}) / (20 * 0.12)$$

Where x_i = average system velocity (mph)

y_i = system deceleration (mph/sec)

The linear regression gives an equation of the general form:

$$y = A (x) + B$$

which is the deceleration due to friction as a function of velocity. In the general form of the equation, A and B are constants, x_i corresponds to "(x)" and y_i corresponds to "y" which is the acceleration (or deceleration). The angular deceleration can be calculated by multiplying "y" by 14.08 (rad/sec)/mph to get the angular deceleration due to friction as a function of velocity (mph).

Block 224 calculates the frictional resistance in the

system in terms of a frictional torque, from the equation:

$$T = Ia$$

Where T = Frictional Torque of alternator (N*m)
I = Mass moment of inertia ($N*m*sec^2$)
a = angular acceleration (rad/sec^2)

The acceleration, or rather deceleration "a" is the value computed by block 222 as a function of velocity. The system inertia is known or can be calculated, and should include the bicycle wheel 14 and tire 16 (Fig. 1). A typical value of the inertia, using a 900 gram wheel, is 0.06296 $N*m*sec^2$. The result calculated by block 224 is the frictional torque of the system under a no load condition. The constants A and B from block 224 are stored in RAM as shown in block 226.

The power to overcome the frictional torque as calculated above can be computed from the equation:

$$P = T * w$$

where: P = Power (watts)
T = Torque (N * m)
w = angular velocity (rad/sec)

Block 227 uses this equation and the above data, with the appropriate conversion factors, to derive the power lost to friction in terms of the linear regression variables A and B:

$$P_f = 11.829 * v * [A * v + B]$$

where: P_f = power lost to friction (watts)
v = bicycle velocity (mph)
A = linear regression constant
B = linear regression constant

The power lost to friction, P_f, represents the power lost in the system, including frictional power losses from the alternator 112 (Fig. 2). The stator of the alternator 112 (Fig. 2) may have a residual voltage applied, which although small, can cause frictional drag. By knowing the frictional losses of the system, the alternator 112 (Fig. 2) can apply power to the system to simulate road

conditions, and to compensate for the frictional losses of the system to increase the realism of the simulation.

The accuracy with which real loads are simulated also depends on how efficient the alternator 112 is in simulating the known loads. If the alternator 112 varies from the standard alternator used in deriving the original equations, applied loads will be less than accurate. To calibrate the alternator 112, the sequence then progresses to test 2, as shown in block 228.

Referring to the flow chart of Fig. 13, the power calibration of the alternator is performed by a second test, which determines the efficiency of the alternator 112 (Fig. 2) with respect to a standard alternator for which the performance characteristics are known, as for example, by measurement on a dynamometer. This standard alternator is used to derive the calibration equation for P_A described hereinafter, with m = 1 in that equation. The comparison with the standard alternator allows compensation for variations in the electrical performance of the alternator 113.

The rider is again instructed to pedal the bike to a predetermined speed (preferably 25 mph) by block 230, which causes a visual message to appear on the display 152 (Fig. 1). An audio signal informs the rider when the predetermined speed is reached. At that point the rider remains seated on the saddle 22 (Fig. 1) while the wheel 14 (Fig. 1) begins to coast to a rest. Block 232 begins the coast down test. Block 234 sets the DAC at a predetermined value, preferably 105. The voltage causes the alternator 112 (Fig. 2) to apply a load to the roller 108 (Fig. 2). A mid range load is preferably used, and the 105 DAC value corresponds to a mid range load of about 20 mph.

Block 236 checks the speed beginning at a predetermined value, preferably 23 mph. Block 238 stores the speed in RAM, along with the voltage at the power resistor 243 in the alternator 112 (Fig. 2). This voltage

corresponds to the power out of the alternator 113 (Fig. 2). Decision block 240 checks to see if the speed is below a predetermined value, preferably 15 mph, and if not, it returns to block 236. The loop of blocks 236, 238 and 240 is repeated at periodic intervals, preferably every .12 seconds, until the 15 mph value is reached. At that point, several calculations can be made by the computer 200 (Fig. 1).

Block 242 calculates the power dissipated by the alternator 112(Fig. 2) at a predetermined speed, 20 mph in this case. A regression analysis is performed to determine this value in order to eliminate the possibility of obtaining incorrect information by taking a single power reading at 20 mph. The voltage readings stored in RAM by block 238 are squared, and then a linear regression analysis is performed on the voltage squared as a function of velocity:

$$x_i = v_i$$
$$y_i = (E_i)^2$$

where: x_i = average system velocity (mph)

v_i = incremental velocity readings (mph)

y_i = system deceleration (mph/sec)

E_i = voltage across power resistor 243 (volts)

The regression analysis results in a linear equation having the general form:

$$y = C(x) + D$$

where: y =a variable that corresponds to E_2, the voltage across the power resistor 243, squared (volts)

C = a constant

D = a constant

(x) = a variable corresponding to velocity v (mph)

Thus the immediately preceding equation can be rewritten in the form:

$$E^2 = C * v + D$$

Where: E = voltage across power resistor 243 (volts)
v = velocity (mph)
C = a constant
D = a constant

A one ohm external power resister 243 (Fig. 2) is connected to the alternator 112 (Fig. 2), and the power dissipated by the external resistor 243 is E^2. The power across the external resistor 243 essentially measures the power out of the alternator 113 (Fig. 2). By substituting the velocity of 20 mph the power dissipated at 20 mph can be found.

Block 244 computes the power into the alternator 112 (Fig. 2) as a function of velocity, by performing a linear regression analysis similar to that previously described. This time, however, every 5 speed readings are averaged together to get $v_1, v_2, \ldots v_n$ where the velocity v is between 15 and 23 mph. The regression is performed on the points:

$$x_i = (v_i + v_{i+1}) / 2$$

$$y_i = [(v_i - v_{n+1}) / (5 * 0.12)] * [(v_i + v_{i+1})/2]$$

where: x_i = system velocity (mph)
y_i = deceleration times velocity $(\text{mph})^2/\text{sec}$

The result of this regression is a linear equation, which when multiplied by the proper factors, gives the power into the alternator as a function of velocity:

$$P_i = [F * v + G] * 11.829$$

where: P_i = power into alternator (watts)
v = velocity (mph)
F = regression constant
G = regression constant

Block 246 determines the electrical efficiency of the alternator 112 (Fig. 2) by taking the ratio of the power out, over the power input, at 20 mph.

$$n_u = [(E^2) / (P_{in} - P_f)]_{20\text{ mph}}$$

where: n_u = user's alternator efficiency
E^2 = alternator output (watts)

P_{in} = alternator input power (watts)

P_f = power lost to friction (watts)

Block 248 determines the calibration factor which gages the performance of a particular user's alternator with the performance of the standard alternator used to derive the foregoing equations. The calibration factor is:

$m = n_u / n_{cal}$

where: m = multiplying factor for alternator

n_u = user electrical efficiency

n_{cal} = calibrated alternator efficiency

The calibration factor m is stored in RAM by block 250.

The power a rider puts into the alternator is calculated by knowing the power out of the alternator 112, and the alternator efficiency, as compared to a standard. The voltage is read across the power resistor 243 in the alternator 112 (Fig. 2). The voltage is used to calculate the power exerted by the rider. The power is then multiplied by the calibration factor, m, to compensate for any variations between the user's apparatus, and the standard apparatus.

The display window 212 (Fig. 12) is used to display the power values and associated information for use by the rider. Following the completion of the coast down tests of Figs. 11 and 13, the information displayed includes the linear regression constants A and B from block 224 (Fig. 11), the calibration factor m from block 248 (Fig. 13). The correlation coefficients for such equations as those of blocks 242 and 244 of Fig. 13 can also be displayed.

A computer source code listing for the calibration steps as described generally in Figs. 11 and 13 is attached as Appendix A.

The calibration of Figs. 11 and 13 serves to identify the various factors that can cause the load to vary from what is theoretically predicted. By knowing these variable factors, and calibrating the apparatus to account for these

variables or to compensate for frictional losses, the accuracy of the load that is applied is greatly increased, thus giving an increasingly realistic ride simulation. The increased accuracy of the load simulation works in combination with the increased realism provided by the apparatus on which the bike is mounted as described with respect to Figs. 1-10, in order to provide for a realistic training and exercise apparatus, both as to load exerted, and operational "feel."

Once the apparatus is calibrated, the correct loads must be determined to properly simulate the desired riding conditions. The torque which the alternator 112 presents to the exercise apparatus for the rider to overcome was found to vary linearly with the voltage across the power resistor 243 squared (E^2) for one particular speed with the y-intercept equal to zero, where the voltage squared was plotted on the horizontal (x) axis, and the power was plotted on the vertical (y) axis. The slope of these speed or velocity lines was found to be a function of the exponent of the inverse of the speed, as:

$$\text{slope} = 0.12832 * e^{(1/v)} - 0.12903$$

where: v = rider velocity (mph)

Using this information, the equation for y_i from block 222, the equation for n_u from block 246, and appropriate conversion factors, the power dissipated by the alternator 112 can be written as:

$$P_A = m[14.08 * v * E^2 * (0.1283\ e^{(1/v)} - 0.12903)]$$

where: P_A = alternator power (watts)

E = power resistor voltage (volts)

v = road speed (mph)

m = calibration factor

The computer 200 can accurately simulate the desired environmental loads experienced by a bicycle rider. The appropriate loads are determined as follows, in the preferred embodiment.

The inertia of the bicycle and rider is simulated by

the flywheel 116 (Fig. 2), as previously described. The alternator 112 also has some inertia which must be considered. The inertia of a 22 pound flywheel (0.05648 $N*m*sec^2$) when combined with the inertia of the alternator 112 (Fig. 2) has the same inertia as a 113 pound man with a 25 pound bike.

The rolling resistance of the bike is given by the equation:

$$F_R = 4.448 * C_R * W$$

Where: F_R = rolling friction (N)
C_R = coefficient of friction
W = weight of rider and bicycle (lbs)

This equation assumes the bearing friction is accounted for in the coast down tests of Figs. 11 and 13. A coefficient of friction of .004 is preferably used as a median representation of the friction for good clincher tires on a variety of surfaces.

The aerodynamic drag of a bicycle rider is given by the equation:

$$F_D = 0.54 * A * v^2$$

Where: F_D = air drag (N)
A = frontal area of bicycle and rider (m_2)
v = velocity of bicycle (m/sec)

This drag equation assumes a drag coefficient of 0.9, and the standard air density at sea level. The frontal area A changes with rider position and rider size. Assuming that the frontal area varies linearly with rider weight, and a 125 pound rider has a frontal area of 0.306 m^2 while a 180 pound rider has a frontal areas of 0.409 m^2, and a 25 pound bike with the bike's frontal area included in the preceding figures, then the aerodynamic drag equation becomes:

$$F_D = v^2 [(0.00103 * W) + 0.0113]$$

Where: F_D = air drag (N)
v = velocity of bicycle (m/sec)
W = weight of rider and bicycle (lbs)

If the velocity is given in units of mph, then the first and second constants become 0.000206 and 0.00227 respectively. Further variations in the aerodynamic drag equation can be made if it is desired to simulate race conditions such as the position of a rider within a pack of riders. A 30% reduction in air drag is believed to be appropriate for use in the illustrated embodiment if a rider were within a pack of riders.

Assuming a 25 pound bicycle, the load on a bike rider due to inclined or graded surfaces, such as hills, can be calculated as:

$$F_G = 4.448 * G * W$$

Where: F_G = force due to grade (N)

G = percent grade (e.g. 45% angle = 100% grade)

W = weight of rider and bicycle (lbs)

Since power is equal to force times velocity, the power experienced by a bike rider can be obtained by combining the equations for the above forces, to yield the equation:

$$P_r = 0.447 * v * (F_R + F_D + F_G)$$

Where: P_r = road power for rider (watts)

v = velocity (mph)

F_R = force from rolling resistance (N)

F_D = force from air drag (N)

F_G = force from hills (N)

For given riding conditions from the above equation, the speed for the rider can be calculated, and an appropriate voltage determined to be applied to the alternator 112 in order to simulate that road power. A feedback loop is used in the monitoring and adjustment of the load exerted by the alternator 112. The power a rider is exerting is calculated from the equation:

$$P_{in} = P_A + P_f$$

Where: P_{in} = rider power exerted by rider (watts)

P_A = alternator power into system (watts)

P_f = friction power (watts)

The computer 200 (Fig. 1) controls and modifies the DAC value, which in turn varies the alternator power P_A as needed to simulate the riding conditions. The DAC value is modified according to the equation:

$$DAC_n = DAC_o\ (P_{in} / P_r)$$

Where: DAC_n = new DAC value

DAC_o = previous DAC value

P_{in} = rider power in (watts)

P_r = desired rider power in (watts)

Preferably the DAC_n value is limited to a maximum increase of 40 percent. By using the above load equations and calibration modes, the load experienced by the rider can be varied in a more realistic manner than previously possible.

The computer 200 can be programed to simulate several riding conditions. Referring to Fig. 12, a programming capability is provided whereby the rider can use the keys on the keyboard 252 to select desired loading conditions for specified times and/or speeds. Similarly, the keyboard 252 can be used to recall a stored loading program from the computer 200. One such program is the race mode where the rider competes against other racers simulated by the computer 200.

Fig. 14 shows an exemplary display window 212 for the race mode. A first cursor 254 on the display window 212 indicates the position of the rider in a window 256 which displays the pack position so the rider can visualize his/her position with respect to other racers. The window 212 also displays the rider's speed, the elapsed time, the miles traveled, the cadence or pedal rpm, and the rider's heart rate. An elevation profile 258 of the course and the rider's position on the course is also displayed in the window 212. A second cursor 257 indicates the rider's position on the course so the rider can visualize the rider's position with respect to not only the pack via window 256, but also with respect to the overall course and

race. The blocks in the window 212 labeled "OTB" and "OTF" allow the first cursor 254 to move within and out of the pack a predetermined extent. "OTB" means "off the back" of the pack, and "OTF" means "off the front" of the pack.

The race mode can use preprogrammed race courses, as for example the course used in the 1984 Olympics. Another preprogrammed course would be a constant incline, sometimes referred to as a fixed grade, where the amount of the incline or grade can be selected by the rider. Alternately, the rider can independently program a course created by the rider. In either event, the computer 200 will control the alternator 112 (Fig. 2) to provide the appropriate loads that simulate the terrain traversed over the length of the course. The rider can select the difficulty of the competition by use of the keyboard 252, in order to compete against riders of varying competence. The greater the competence of the riders, the faster the course would be traversed.

In real races, the riders will bunch up to form a "pack" for much of the race. The pack of riders will progress at varying speeds, sometimes maintaining constant speed, while sometimes increasing speed as riders vie for position. The computer 200 is thus programed to vary the pack speed, preferably in a random manner so the rider can decide whether to alter position as the pack speed varies.

As previously mentioned, the load experienced by a rider can vary depending on the rider's position with respect to the pack since the wind resistance is less for riders in the pack than for those riders who lead or trail the pack. There is thus provided a rider controllable position relative to a pack of simulated riders of a preselected capability, with the rider position relative to the pack varying the wind load experienced by the rider.

Fig. 15 shows a flow chart of a race mode simulation, while Appendix B contains a computer source code for this

simulation and related pack position and power calculations. Block 260 allows the rider to select the level of competition for the race. The more difficult the competition, the greater the loads which must be exerted by the rider on the apparatus in order to keep up with the competition. The loads exerted on the rider by the exercise apparatus, however, are determined by the selected race course as simulated by the alternator 112 (Fig. 2).

The selection of the race course or of the level of competition from the simulated riders is made by using the keyboard 252. Block 262 allows the rider to select the racecourse. A fixed grade may be input, a preprogrammed course can be selected, or a new course can be input by the rider, again by using the keyboard 252 in conjunction with computer algorithms. Block 264 allows the rider's weight to be entered since that affects the load simulation.

Block 266 reads the A/D converter which in turn reads the analog voltage across the external power resistor 243 connected to the alternator 112 (Fig. 2). Block 268 converts that analog voltage to a digital value where the digital value is linear with a maximum of 255. The 255 digital value corresponds to a voltage of 25 volts. Block 270 then computes the appropriate power for the given road simulation according to the formula:

$$P_{total} = P_f + P_A$$

Where: P_{total} = total power to be overcome by rider (watts)

P_f = power lost to friction (watts)

P_A = alternator power (watts)

The equations for P_f and P_A have been previously defined.

Block 272 averages the total power P_{total} over a one second period and displays that power on the display unit 152 (Fig. 1). Block 274 computes the pack power based on the level of experience selected by the rider. Block 276 computes the pack distance to determine the position on the

racecourse. Block 278 displays the position of the rider with respect to the pack position, via window 256 (Fig. 14). Block 280 checks the speed of the rider so that block 282 can compute the wind force on the rider, using the previously discussed formula for air drag F_D.

Decision block 286 checks to determine if the rider is within the pack, and if so, block 286 reduces the air drag to account for the reduced wind resistance from being in the pack. The reduction is 30 % in the described embodiment. Block 288 computes the loads from the grade and rolling resistance, F_G and F_R, as previously discussed. Block 290 computes the desired power, P_r, as previously described, to be applied to the alternator 112 (Fig. 2) to simulate the above combination of loads.

Once the desired amount of power needed to simulate the riding conditions is determined, decision block 292 checks to see if the desired power is equal to the actual power resistance being exerted on the apparatus by the alternator 112 (Fig. 2) and inherent friction in the system. If the desired power is the same power being applied, no adjustment is necessary and the computer algorithm of Fig. 15 returns to block 266.

If the desired power is not equal to the power being applied, then the program proceeds on to block 294 which computes the percentage ratio of the desired power and applied power. Decision block 296 determines whether this percentage difference is within predetermined limits of acceptability. A 40% difference in the percentage ratio acceptable in the described embodiment. If the percentage difference is beyond the predetermined value, the program proceeds to block 298 where the percentage ratio is adjusted. To prevent sudden surges in load variability, any adjustment of the percentage ratio is limited so as not to exceed a predetermined range, which is plus or minus 40%. in the illustrated embodiment. A no decision from block 296 leads to block 300, as does the natural exit from

block 298. Block 300 calculates a new DAC value according to the equation:

$$DAC_{new} = (\%)(DAC_{old})$$

Where: DAC_{new} = new DAC value (volts)

DAC_{old} = prior DAC value (volts)

% = percentage ratio from block 294 or 298.

Following the adjustment of the DAC value, the program returns to block 266 for another iteration. These iterations are repeated at least every second. This computer algorithm allows the rider to train, practice, and experience the exertion required to participate in well recognized courses, in a realistic simulation, and monitor the rider's performance on an absolute time basis, and on a relative basis with respect to a pack of riders having a predetermined ability.

Another capability of the apparatus is to monitor the rider's heart rate, and adjust the load experienced by the rider to maintain the heart rate within predetermined limits. A flow chart of a computer program to achieve this purpose is shown in Fig. 16. A copy of a computer source code implementing this flow chart is attached as Appendix C.

The rider initiates the program by keying in the request from keyboard 252 (Fig. 12). Block 300 initiates the program and 226-Arts requests the rider to input information on the upper and lower limits for the heart rate. If no values are input, a default program (not shown) displays a request on window 212 that the rider input the age and sex of the rider, which information is input by keyboard 252. For males, the maximum heart rate is calculated as 220 minus the age. For females, the maximum heart rate is calculated as 226 minus the age. Using this information, limits of 70 to 85% the maximum attainable heart rate during an all out effort are selected from data accessible to computer 200 (Fig. 1).

Block 301 sets the DAC to zero so there is no load

exerted by the alternator 112 (Fig. 2), and tells the rider to warm up by a display message in display window 212. As indicated in block 302, the warm up lasts for a predetermined time, two minutes in this case.

Preferably, the rider makes the necessary connections before the warmup period begins so that information on the rider's heart rate can be input into the computer 200 in the display unit 152 (Fig. 1). Various methods known in the art can be used to monitor the rider's heart rate and transmit it to the computer. Preferably, however, the rider wears a chest belt containing a pulse sensor to sense the rider's heart rate. The belt also preferably contains a transmitter so the information can be transmitted to a receiver in the computer 200 in the display unit 152 (Fig. 1). Such devices are known in the art and are not descried in detail herein.

The upper limit (UL) and lower limit (LL) are used in the decision block 306 to determine whether the heart rate (HR) is such that the load exerted on the apparatus by the alternator 112 (Fig. 2) should be increased, decreased, or remain the same. Decision block 306 monitors the heart rate, and if it is within a predetermined range then the load is not altered as indicated in block 310, and the display window displays a signal to indicate all is well, as in block 312, after which the program returns to recheck the heart rate. The predetermined range selected in Fig. 16 is that the heart rate must be greater than:

$$LL + (UL - LL) * .2$$

and less than:

$$UL - (UL - LL) * .2$$

Where: LL = lower limit (from block 306)

UL = upper limit (from block 306)

Essentially, no consideration is given to changing the load until the heart rate approaches to within 20% of either the upper or lower limits.

If the heart rate was within 20% of the lower heart rate limit, then the algorithm proceeds to decision block 320 which checks to see if the DAC value just recently increased. Since the DAC value affects the load exerted by the alternator 112 (Fig. 2), this step essentially checks to see if the load exerted on the rider has recently increased. If the answer is no, the algorithm proceeds to block 324. If the answer is yes, the algorithm proceeds to block 322 which checks to determine whether the DAC value has been unchanged for more than a predetermined time, 40 seconds in this case. This step is essentially checking to see if the load exerted on the rider has been unchanged for 40 seconds. If the DAC value has not changed for at least 40 seconds, the program returns to block 306 and re-reads the heart rate. If the DAC value has not changed for 40 seconds or more, the program proceeds to decision block 324, which checks to see if the DAC value is at a predetermined level, which in this case is selected as 255. As previously mentioned, 255 is the maximum DAC value, and corresponds to a voltage of 12 volts at the field coil of alternator 112 (Fig. 2). If the DAC value is 255, the program goes to block 326 which displays a request for the rider to increase the effort being exerted, after which it returns to block 306. If the DAC value is below 255, then the program proceeds to block 328 which increases the power by a predetermined amount, which was selected as 10 watts in the preferred embodiment. The program then returns to decision block 306.

If the rider's heart rate is within 20 % of the upper heart rate limit, then the program goes to decision block 330 which checks to see if the heart rate has exceeded the upper limit by a predetermined amount, which was selected to be 5 in Fig. 16. If the answer is yes, the heart rate is too high and the program goes to block 332 which sets the DAC to zero to reduce the load, displays a signal on the display unit 152 (Fig. 1) telling the rider to decrease

effort, and gives an audio signal (a beep) until the heart rate is lowered to within the pre-specified limits. The program then returns to block 306 to check the heart rate.

If the decision from block 330 is that the rider's heart rate is not greater than the predetermined amount, then the program goes to decision block 334, which checks to see if the DAC was just decreased. If it has just decreased, then the program proceeds to decision block 336 to see how long the heart rate has been heart rate has been above the upper limit. If the DAC has not just decreased, then the algorithm proceeds to block 338.

Block 336 checks to see whether the DAC has changed within the last 20 seconds, and if so the program returns to block 306. If the DAC has been unchanged for 20 seconds or more, then the program proceeds to decision block 338.

Block 338 checks the DAC value, and if it is zero, the program proceeds to block 332 which was previously described. If the DAC value is not zero, then block 340 decreases the power to the alternator 112 (Fig. 2) by a predetermined amount, which is 10 watts in Fig. 16. After decreasing the power, the program returns to block 306.

The algorithm of Fig. 16 thus maintains the load on the exercise apparatus so that the heart rate stays within predetermined limits, and initiates corrective measures as the heart rate approaches those limits. The fast and accurate response of the alternator 112 (Fig. 2) to the load variations allows the loads to be adjusted quickly and accurately enough to maintain the heart rate within the preselected limits. The display unit 152 (Fig. 1) provides visual and audio communication to the rider to further maintain the effectiveness of the system.

When combined with the prior improvements, the method and apparatus for controlling the heart rate allows a racer to optimize the training for a race. The apparatus for supporting the racer's bicycle provides a realistic ride simulation or "feel." The calibration of the friction and

alternator efficiency allow the loads to be accurately simulated and to accurately simulate various race conditions. The effects of wind load and pack position can be simulated. The computer and race course selection allows a variety of races to be simulated, so the rider can practice any pre-programmed course, or program independently. The ability to select various levels of competition, and to race against the simulated competition provides race incentive. The random variation of pack performance during a race allows the racer to practice various race strategies. The heart rate monitor allows the racer to track physical performance while having the exercise device take steps to control the load which affects the heart rate.

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                ;COPYRIGHT 1986 FRONTLINE TECHNOLOGY, INC.
F743*           CALIBRATE
F743*4C3DE1     JMP MM0 ;^FOR NOW
F746*9C0C02     STZ DACTMP ;ZERO THESE
F749*9C6402     STZ STARTFLG
F74C*9C2102     STZ SIGNFLG
F74F*A900       LDA #0
F751*8DA07F     STA $7FA0 ;0 DAC
F754*2099D6     JSR RESVAL ;RESET ALL VALUES

F757*           CALIBRATE0
F757*200FF9     JSR CALIBDSP ;"CALIBRATE" AND "SPEED"
F75A*A922       LDA #$22
F75C*8501       STA ADDR+1
F75E*6400       STZ ADDR
F760*A96E       LDA #LOW M286 ;"PRESS THE "START" MENU KEY TO BEGIN CALIBRATION"
F762*A053       LDY #HIGH M286
F764*2058A3     JSR PRTMSG
F767*A924       LDA #$24
F769*8501       STA ADDR+1
F76B*A99F       LDA #LOW M287 ;"PRESS THE "HELP"..."
F76D*A053       LDY #HIGH M287
F76F*2058A3     JSR PRTMSG


F772*A998       LDA #LOW M195 ;"START"
F774*A04E       LDY #HIGH M195
F776*20E7DA     JSR INVMSGC1 ;1ST SOFTKEY
F779*A96E       LDA #LOW M65 ;"PREVIOUS MENU"
F77B*A041       LDY #HIGH M65
F77D*20F4DA     JSR INVMSGC2 ;2ND SOFTKÈY
F780*A9FC       LDA #LOW M81 ;"MAIN MENU"
F782*A042       LDY #HIGH M81
F784*2001DB     JSR INVMSGC3 ;3RD SOFTKEY


F787*           CALIBRATE2
F787*645F       STZ KEY

F789*           CALIBRATE3
F789*A55F       LDA KEY ;ANYTHING FROM KEYBOARD?
F78B*F0FC       BEQ CALIBRATE3 ;NO
F78D*C911       CMP #$11 ;START
F78F*F015       BEQ CALIBRATE5
F791*C912       CMP #$12 ;PREVIOUS MENU
F793*D003       BNE *+5
F795*4CC7C0     JMP SETUP
F798*C913       CMP #$13 ;MAIN MENU
F79A*D003       BNE *+5
F79C*4C3DE1     JMP MM0
F79F*C93F       CMP #'?' ;HELP
F7A1*D0E4       BNE CALIBRATE2

                ;HELP MENU HERE
```

```
F7A3*2068BE       JSR BEEP

F7A6*             CALIBRATE5 ;START
F7A6*8DB07F       STA $7FB0 ;START A/D
F7A9*AD0A02       LDA STARTFLG ;SAVE
F7AC*48           PHA
F7AD*2089D6       JSR RESVAL ;RESET ALL VALUES
F7B0*68           PLA
F7B1*8D0A02       STA STARTFLG ;RESTORE
F7B4*2068BE       JSR BEEP
F7B7*200FF9       JSR CALIBDSP ;"CALIBRATE" AND "SPEED"
F7BA*A922         LDA #$22
F7BC*8501         STA ADDR+1
F7BE*6400         STZ ADDR
F7C0*A9CA         LDA #LOW M288 ;"PEDAL YOUR BICYCLE..."
F7C2*A053         LDY #HIGH M288
F7C4*2058A3       JSR PRTMSG
F7C7*A980         LDA #$80
F7C9*8500         STA ADDR
F7CB*A900         LDA #LOW M289 ;"YOU HEAR THE BEEP."
F7CD*A054         LDY #HIGH M289
F7CF*2058A3       JSR PRTMSG


F7D2*A939         LDA #LOW M291 ;"CANCEL"
F7D4*A054         LDY #HIGH M291
F7D6*20E7DA       JSR INVMSGC1 ;1ST SOFTKEY
F7D9*209FA8       JSR IRQENABLE ;ENABLE IRQ'S
F7DC*A9C3         LDA #LOW DACDAT ;BEGINNING RAM FOR SPEED
F7DE*851C         STA PNT14
F7E0*A905         LDA #HIGH DACDAT
F7E2*851D         STA PNT14+1
F7E4*A9A0         LDA #LOW CRSDAT ;BEGINNING RAM FOR VOLTAGE
F7E6*851A         STA PNT13
F7E8*A90E         LDA #HIGH CRSDAT
F7EA*851B         STA PNT13+1
F7EC*9C0B02       STZ EXPFLG ;CLR FLG

F7EF*             CALIBRATE6
F7EF*645F         STZ KEY
F7F1*9C2102       STZ SIGNFLG

F7F4*             CALIBRATE7
F7F4*A55F         LDA KEY ;ANYTHING FROM KEYBOARD?
F7F6*D007         BNE CALIBRATE8 ;YES
F7F8*A5A4         LDA TIMER3 ;0.12 SEC?
F7FA*D00A         BNE CALIBRATE9 ;NO
F7FC*4CBCF8       JMP CALIBRATE11

F7FF*             CALIBRATE8
F7FF*C911         CMP #$11 ;CANCEL
F801*D0EC         BNE CALIBRATE6
F803*4C43F7       JMP CALIBRATE

F806*             CALIBRATE9 ;0.12 SEC
```

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Module: EIPIL

```
F806*202E9D      JSR ADAVG ;RUNNING 10 A/D READINGS
F809*A544        LDA RPMFLG ;A SPEED PULSE YET?
F80B*F0E7        BEQ CALIBRATE7 ;NO
F80D*2062E7      JSR RPMCALC ;CALCULATE SPEED
F810*2C0B02      BIT EXPFLG
F813*7065        BVS CALIBRATE10A ;ALREADY PAST 23 MPH ON COAST DOWN
F815*3042        BMI CALIBRATE10 ;PAST 25 MPH ON UP SIDE
F817*AD2903      LDA SPDHEX ;>25.5 MPH?
F81A*D007        BNE CALIBRATE9A ;YES
F81C*AD2A03      LDA SPDHEX+1 ;25 MPH YET?
F81F*C9FA        CMP #250
F821*90CC        BCC CALIBRATE6 ;NO

F823*            CALIBRATE9A
F823*AD2102      LDA SIGNFLG ;2 TIMES? (MINIMIZE NOISE)
F826*D005        BNE CALIBRATE9A1 ;YES
F828*EE2102      INC SIGNFLG
F82B*80C7        BRA CALIBRATE7

F82D*            CALIBRATE9A1
F82D*20688E      JSR BEEP
F830*A980        LDA #$80
F832*8D0B02      STA EXPFLG
F835*200FF9      JSR CALIBDSP ;"CALIBRATE" AND "SPEED"
F838*A922        LDA #$22
F83A*8501        STA ADDR+1
F83C*6400        STZ ADDR
F83E*A918        LDA #LOW M290 ;"CONTINUE COASTING..."
F840*A054        LDY #HIGH M290
F842*2058A3      JSR PRTMSG
F845*A939        LDA #LOW M291 ;"CANCEL"
F847*A054        LDY #HIGH M291
F849*20E7DA      JSR INVMSGC1 ;1ST SOFTKEY
F84C*2C0A02      BIT STARTFLG ;DAC 105? (2ND COASTDOWN)
F84F*109E        BPL CALIBRATE6 ;NO
F851*A969        LDA #105 ;LOAD DAC WITH 105
F853*8DA07F      STA $7FA0
F856*4CEFF7      JMP CALIBRATE6

F859*            CALIBRATE10
F859*AD2903      LDA SPDHEX ;>255?
F85C*D091        BNE CALIBRATE6 ;YES
F85E*AD2A03      LDA SPDHEX+1
F861*C9E7        CMP #231 ;CROSSED 230 YET?
F863*9003        BCC *+5
F865*4CEFF7      JMP CALIBRATE6 ;NO
F868*AD2102      LDA SIGNFLG ;2 TIMES?
F86B*D005        BNE CALIBRATE10AA ;YES
F86D*EE2102      INC SIGNFLG
F870*8082        BRA CALIBRATE7

F872*            CALIBRATE10AA
F872*A9FF        LDA #$FF
F874*8D0B02      STA EXPFLG
F877*4CEFF7      JMP CALIBRATE6
```

```
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                                                            Module:  BIKIA

F87A*           CALIBRATE10A
F87A*2C0A02     BIT STARTFLG ;0 OR 105?
F87D*101D       BPL CALIBRATE10B ;0
F87F*AD2A03     LDA SPDHEX+1
F882*C997       CMP #151 ;15 MPH YET?
F884*9003       BCC *+5
F886*4CEFF7     JMP CALIBRATE6
F889*AD2102     LDA SIGNFLG ;2 TIMES?
F88C*D006       BNE CALIBRATE10A1 ;YES
F88E*EE2102     INC SIGNFLG
F891*4CF4F7     JMP CALIBRATE7

F894*           CALIBRATE10A1
F894*A900       LDA #0
F896*8DA07F     STA $7FA0 ;RE-ZERO DAC
F899*4C47FA     JMP CALDAC105 ;^FOR NOW

F89C*           CALIBRATE10B
F89C*AD2A03     LDA SPDHEX+1
F89F*C933       CMP #51 ;CROSSED 5 MPH YET?
F8A1*9003       BCC *+5
F8A3*4CEFF7     JMP CALIBRATE6 ;NO
F8A6*AD2102     LDA SIGNFLG ;2 TIMES?
F8A9*D006       BNE CALIBRATE10B1 ;YES
F8AB*EE2102     INC SIGNFLG
F8AE*4CF4F7     JMP CALIBRATE7

F8B1*           CALIBRATE10B1
F8B1*2058F9     JSR CALDAC0 ;DO CALCULATION FOR 0
F8B4*A9FF       LDA #$FF
F8B6*8D0A02     STA STARTFLG
F8B9*4CA6F7     JMP CALIBRATE5


F8BC*           CALIBRATE11 ;DISPLAY SPEED
F8BC*A903       LDA #3
F8BE*85A4       STA TIMER3
F8C0*202DF9     JSR SPEEDISP
F8C3*2C0B02     BIT EXPFLG ;CALIBRATION RUNNING?
F8C6*5044       BVC CALIBRATE12 ;NO
F8C8*A000       LDY #0
F8CA*AD2A03     LDA SPDHEX+1 ;STORE SPEED
F8CD*911C       STA (PNT14),Y
F8CF*E61C       INC PNT14
F8D1*D002       BNE *+4
F8D3*E61D       INC PNT14+1
F8D5*A51D       LDA PNT14+1
F8D7*C940       CMP #$40 ;OUT OF RAM?
F8D9*D006       BNE CALIBRATE11A ;NO
                ;OVER RAM LIMIT - DISPLAY SOMETHING
F8DB*2068BE     JSR BEEP
F8DE*4CDEF8     JMP *

F8E1*           CALIBRATE11A
```

```
F8E1*2C0A02        BIT STARTFLG
F8E4*1026          BPL CALIBRATE12 ;DAC0

F8E6*              CALIBRATE11B
F8E6*A000          LDY #0
F8E8*AD4904        LDA ADTOT ;STORE A/D SUM OF 10 READINGS
F8EB*911A          STA (PNT13),Y
F8ED*C8            INY
F8EE*AD4A04        LDA ADTOT+1
F8F1*911A          STA (PNT13),Y
F8F3*18            CLC
F8F4*A51A          LDA PNT13
F8F6*6902          ADC #2
F8F8*851A          STA PNT13
F8FA*A51B          LDA PNT13+1
F8FC*6900          ADC #0
F8FE*851B          STA PNT13+1
F900*A51B          LDA PNT13+1
F902*C940          CMP #$40 ;OUT OF RAM?
F904*D006          BNE CALIBRATE12 ;NO
                   ;OVER RAM - DISPLAY SOMETHING
F906*2068BE        JSR BEEP
F909*4C09F9        JMP *

F90C*              CALIBRATE12
F90C*4CF4F7        JMP CALIBRATE7


F90F*              CALIBDSP ;DISPLAY "CALIBRATE" AND "SPEED"
F90F*206BA3        JSR CLRDSP
F912*20C3F5        JSR HVLIN ;HORIZ AND VERT LINES
F915*6400          STZ ADDR
F917*A920          LDA #$20
F919*8501          STA ADDR+1
F91B*A9A9          LDA #LOW M198 ;"CALIBRATION"
F91D*A04E          LDY #HIGH M198
F91F*2058A3        JSR PRTMSG
F922*A924          LDA #$24
F924*8501          STA ADDR+1
F926*A91E          LDA #LOW M213 ;"SPEED"
F928*A04F          LDY #HIGH M213
F92A*4C58A3        JMP PRTMSG

F92D*              SPEEDISP ;DISPLAY SPEED
F92D*AD2903        LDA SPDHEX
F930*856C          STA HEX+1
F932*AD2A03        LDA SPDHEX+1
F935*856D          STA HEX+2
F937*646B          STZ HEX
F939*201FBA        JSR HEXASC
F93C*A924          LDA #$24
F93E*8501          STA ADDR+1
F940*6400          STZ ADDR
F942*A568          LDA ASCI+5
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F944*A006       LDY #6
F946*9100       STA (ADDR),Y
F948*C8         INY
F949*A569       LDA ASCI+6
F94B*9100       STA (ADDR),Y
F94D*C8         INY
F94E*A92E       LDA #'.'
F950*9100       STA (ADDR),Y
F952*C8         INY
F953*A56A       LDA ASCI+7
F955*9100       STA (ADDR),Y
F957*60         RTS

F958*           CALDAC0:COAST DOWN (0 DAC) COMPLETE

F958*A9C3       LDA #LOW DACDAT ;BEGIN SPEED RAM
F95A*851E       STA PNT15
F95C*A905       LDA #HIGH DACDAT
F95E*851F       STA PNT15+1
F960*20C5FD     JSR RESCALVAL ;RESET CALIB VALUES

F963*           CALDAC0F
F963*6428       STZ MCAND
F965*6429       STZ MCAND+1
F967*A000       LDY #0
F969*A213       LDX #19

F96B*           CALDAC0G ;SUM OF 20 SPEEDS
F96B*18         CLC
F96C*B11E       LDA (PNT15),Y
F96E*6529       ADC MCAND+1
F970*8529       STA MCAND+1
F972*A900       LDA #0
F974*6528       ADC MCAND
F976*8528       STA MCAND
F978*CA         DEX
F979*3008       BMI CALDAC0H
F97B*2036FA     JSR INCPNT15 ;NEXT POINT
F97E*D0EB       BNE CALDAC0G ;NOT DONE YET
F980*4CEDF9     JMP CALDAC0K ;YES

F983*           CALDAC0H
F983*2033F4     JSR RDYFAC
F986*A529       LDA MCAND+1
F988*85DA       STA FACLO
F98A*A528       LDA MCAND
F98C*85D9       STA FACMO
F98E*207565     JSR NORMAL ;NORMALIZE TO FLOATING POINT
F991*A268       LDX #LOW FACTMP1 ;STORE
F993*A003       LDY #HIGH FACTMP1
F995*200D68     JSR MOVMF
F998*AD4903     LDA HRTCNT ;1ST TIME?
F99B*F03A       BEQ CALDAC0I ;YES
F99D*A96D       LDA #LOW FACTMP2 ;GET LAST AVG
F99F*A003       LDY #HIGH FACTMP2
```

```
F9A1*20ED64      JSR FSUB ;LAST - THIS AVG
F9A4*204568      JSR MOVAF
F9A7*A991        LDA #LOW INT480 ;480  20*.12*20(AVG)*10(SPEED)
F9A9*A064        LDY #HIGH INT480
F9AB*20DF67      JSR MOVFM
F9AE*20EAFD      JSR FPDIV
F9B1*A263        LDX #LOW FACTMP ;Y
F9B3*A003        LDY #HIGH FACTMP
F9B5*200D68      JSR MOVMF

F9B8*A968        LDA #LOW FACTMP1 ;THIS READING
F9BA*A003        LDY #HIGH FACTMP1
F9BC*20DF67      JSR MOVFM
F9BF*A96D        LDA #LOW FACTMP2 ;LAST READ
F9C1*A003        LDY #HIGH FACTMP2
F9C3*200465      JSR FADD

F9C6*A9B4        LDA #LOW INT0025 ;0.0025  1/(2*20(AVG)*10(SPEED))
F9C8*A064        LDY #HIGH INT0025
F9CA*206566      JSR FMULT
F9CD*A27C        LDX #LOW ARGTMP ;X
F9CF*A003        LDY #HIGH ARGTMP
F9D1*200D68      JSR MOVMF

F9D4*2038FC      JSR LINREG

F9D7*            CALDAC0I
F9D7*A204        LDX #4 ;STORE THIS AS LAST READ

F9D9*            CALDAC0J
F9D9*BD6803      LDA FACTMP1,X
F9DC*9D6D03      STA FACTMP2,X
F9DF*CA          DEX
F9E0*10F7        BPL CALDAC0J
F9E2*EE4903      INC HRTCNT
F9E5*2036FA      JSR INCPNT15 ;NEXT POINT
F9E8*F003        BEQ CALDAC0K ;DONE
F9EA*4C63F9      JMP CALDAC0F ;NEXT AVG

F9ED*            CALDAC0K
F9ED*2033F4      JSR RDYFAC
F9F0*CE4903      DEC HRTCNT
F9F3*AD4903      LDA HRTCNT ;NEED TO DECREMENT?
F9F6*85DA        STA FACLO
F9F8*20B6FC      JSR ACALC
F9FB*A99B        LDA #LOW INT11829 ;11.829
F9FD*A064        LDY #HIGH INT11829
F9FF*206566      JSR FMULT
FA02*A2E3        LDX #LOW FPV2
FA04*A004        LDY #HIGH FPV2
FA06*200D68      JSR MOVMF

FA09*2023FD      JSR BCALC
FA0C*A99B        LDA #LOW INT11829
FA0E*A064        LDY #HIGH INT11829
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FA10*206566     JSR FMULT
FA13*A2DE       LDX #LOW FPV
FA15*A004       LDY #HIGH FPV
FA17*200D68     JSR MOVMF

FA1A*20B0FD     JSR LINREG20 ;CALC AT 20 MPH??
FA1D*A9A0       LDA #LOW INT236.58 ;236.58
FA1F*A064       LDY #HIGH INT23658
FA21*206566     JSR FMULT
FA24*A2E8       LDX #LOW FPFR20
FA26*A004       LDY #HIGH FPFR20
FA28*200D68     JSR MOVMF
FA2B*2061FD     JSR RCALC ;DISPLAY R SOMEWHERE????
FA2E*A2CA       LDX #LOW FPARG
FA30*A003       LDY #HIGH FPARG
FA32*200D68     JSR MOVMF
                ;JSR DUMPDATA
FA35*60         RTS
                ;END DAC 0 CALIBRATION


FA36*           INCPNT15
FA36*E61E       INC PNT15
FA38*D002       BNE *+4
FA3A*E61F       INC PNT15+1
FA3C*A51E       LDA PNT15 ;DONE?
FA3E*C51C       CMP PNT14
FA40*D004       BNE INCPNT15A ;NO
FA42*A51F       LDA PNT15+1
FA44*C51D       CMP PNT14+1

FA46*           INCPNT15A
FA46*60         RTS

                ;START DAC 105 CALCULATION

FA47*           CALDAC105
FA47*20C5FD     JSR RESCALVAL
FA4A*A9C3       LDA #LOW DACDAT ;SPEEDS
FA4C*851E       STA PNT15
FA4E*A905       LDA #HIGH DACDAT
FA50*851F       STA PNT15+1
FA52*A9A0       LDA #LOW CRSDAT ;VOLTAGES
FA54*851A       STA PNT13
FA56*A90E       LDA #HIGH CRSDAT
FA58*851B       STA PNT13+1

FA5A*           DAC105F
FA5A*2033F4     JSR RDYFAC
FA5D*A000       LDY #0
FA5F*B11E       LDA (PNT15),Y
FA61*85DA       STA FACLO
FA63*207565     JSR NORMAL
FA66*203B67     JSR DIV10
FA69*A27C       LDX #LOW ARGTMP ;X
```

```
FA6B*A003       LDY #HIGH ARGTMP
FA6D*200D65     JSR MOVMF

FA70*2033F4     JSR RDYFAC
FA73*A000       LDY #0
FA75*B11A       LDA (PNT13),Y
FA77*85D9       STA FACMO
FA79*C8         INY
FA7A*B11A       LDA (PNT13),Y
FA7C*85DA       STA FACLO
FA7E*207565     JSR NORMAL
FA81*A9C4       LDA #LOW INT9765 ;NORMALIZE TO VOLTS
FA83*A063       LDY #HIGH INT9765
FA85*206566     JSR FMULT
FA88*A2C5       LDX #LOW FPACC
FA8A*A003       LDY #HIGH FPACC
FA8C*200D68     JSR MOVMF
FA8F*A9C5       LDA #LOW FPACC
FA91*A003       LDY #HIGH FPACC
FA93*206566     JSR FMULT ;^2
FA96*A263       LDX #LOW FACTMP ;Y
FA98*A003       LDY #HIGH FACTMP
FA9A*200D68     JSR MOVMF

FA9D*2038FC     JSR LINREG
FAA0*2036FA     JSR INCPNT15
FAA3*D003       BNE DAC105G ;NOT DONE YET
FAA5*4CC1FA     JMP DAC105K

FAA8*           DAC105G
FAA8*18         CLC
FAA9*A51A       LDA PNT13
FAAB*6902       ADC #2
FAAD*851A       STA PNT13
FAAF*A51B       LDA PNT13+1
FAB1*6900       ADC #0
FAB3*851B       STA PNT13+1
FAB5*E629       INC MCAND+1 ;NUMBER OF POINTS
FAB7*F003       BEQ *+5
FAB9*4C5AFA     JMP DAC105F
FABC*E628       INC MCAND
FABE*4C5AFA     JMP DAC105F

FAC1*           DAC105K
FAC1*2033F4     JSR RDYFAC
FAC4*18         CLC
FAC5*A529       LDA MCAND+1
FAC7*6901       ADC #1
FAC9*85DA       STA FACLO ;NEED TO DECREMENT BY 1?
FACB*A528       LDA MCAND
FACD*6900       ADC #0
FACF*85D9       STA FACMO
FAD1*20B6FC     JSR ACALC
FAD4*2023FD     JSR BCALC
FAD7*20B0FD     JSR LINREG20 ;CALC VALUE AT 20 MPH
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```
FADA*A2ED        LDX #LOW FPE20
FADC*A004        LDY #HIGH FPE20
FADE*200D68      JSR MOVMF
FAE1*2061FD      JSR RCALC ;DISPLAY SOMEWHERE???
FAE4*A2A2        LDX #LOW FPWIND
FAE6*A004        LDY #HIGH FPWIND
FAE8*200D68      JSR MOVMF
FAEB*20C5FD      JSR RESCALVAL
FAEE*A903        LDA #LOW DACDAT
FAF0*851E        STA PNT15
FAF2*A905        LDA #HIGH DACDAT
FAF4*851F        STA PNT15+1

FAF6*            DAC105L
FAF6*6428        STZ MCAND
FAF8*6429        STZ MCAND+1
FAFA*A000        LDY #0
FAFC*A204        LDX #4

FAFE*            DAC105M
FAFE*18          CLC
FAFF*B11E        LDA (PNT15),Y
FB01*6529        ADC MCAND+1
FB03*8529        STA MCAND+1
FB05*A900        LDA #0
FB07*6528        ADC MCAND
FB09*8528        STA MCAND
FB0B*CA          DEX
FB0C*3008        BMI DAC105N
FB0E*2036FA      JSR INCPNT15
FB11*D0EB        BNE DAC105M
FB13*4C91FB      JMP DAC105R

FB16*            DAC105N
FB16*2033F4      JSR RDYFAC
FB19*A529        LDA MCAND+1
FB1B*85DA        STA FACLO
FB1D*A528        LDA MCAND
FB1F*85D9        STA FACMO
FB21*207565      JSR NORMAL
FB24*A266        LDX #LOW FACTMP1
FB26*A003        LDY #HIGH FACTMP1
FB28*200D68      JSR MOVMF
FB2B*AD4903      LDA HRTCNT ;1ST READING?
FB2E*D003        BNE *+5
FB30*4C7BFB      JMP DAC105P ;YES
FB33*A96D        LDA #LOW FACTMP2 ;LAST READ
FB35*A003        LDY #HIGH FACTMP2
FB37*20ED64      JSR FSUB
FB3A*A9A5        LDA #LOW INT033 ;.033333   1/(5*.12*10*5)
FB3C*A064        LDY #HIGH INT033
FB3E*206566      JSR FMULT
FB41*A263        LDX #LOW FACTMP ;Y
FB43*A003        LDY #HIGH FACTMP
FB45*200D68      JSR MOVMF
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```
FB49*A968        LDA #LOW FACTMP1
FB4A*A003        LDY #HIGH FACTMP1
FB4C*20DF67      JSR MOVFM
FB4F*A96D        LDA #LOW FACTMP2
FB51*A003        LDY #HIGH FACTMP2
FB53*200465      JSR FADD
FB56*204568      JSR MOVAF
FB59*A919        LDA #LOW INT100 ;2*5*10
FB5B*A064        LDY #HIGH INT100
FB5D*20DF67      JSR MOVFM
FB60*20EAFD      JSR FPDIV
FB63*A27C        LDX #LOW ARGTMP ;X
FB65*A003        LDY #HIGH ARGTMP
FB67*200D68      JSR MOVMF
FB6A*A963        LDA #LOW FACTMP
FB6C*A003        LDY #HIGH FACTMP
FB6E*206566      JSR FMULT
FB71*A263        LDX #LOW FACTMP ;Y
FB73*A003        LDY #HIGH FACTMP
FB75*200D68      JSR MOVMF
FB78*2038FC      JSR LINREG

FB7B*            DAC105P
FB7B*A204        LDX #4

FB7D*            DAC105Q ;THIS READ TO LAST READING
FB7D*BD6803      LDA FACTMP1,X
FB80*9D6D03      STA FACTMP2,X
FB83*CA          DEX
FB84*10F7        BPL DAC105Q
FB86*EE4903      INC HRTCNT ;NUMBER OF POINTS
FB89*2036FA      JSR INCPNT15 ;NEXT POINT
FB8C*F003        BEQ DAC105R ;DONE
FB8E*4CF6FA      JMP DAC105L ;NEXT AVG

FB91*            DAC105R
FB91*2033F4      JSR RDYFAC
FB94*CE4903      DEC HRTCNT
FB97*AD4903      LDA HRTCNT
FB9A*85DA        STA FACLO
FB9C*20B6FC      JSR ACALC
FB9F*2023FD      JSR BCALC
FBA2*20B0FD      JSR LINREG20
FBA5*A99B        LDA #LOW INT11829
FBA7*A064        LDY #HIGH INT11829
FBA9*206566      JSR FMULT
FBAC*204568      JSR MOVAF
FBAF*A9E8        LDA #LOW FPFR20
FBB1*A004        LDY #HIGH FPFR20
FBB3*20DF67      JSR MOVFM
FBB6*20F064      JSR FSUBT
FBB9*A9ED        LDA #LOW FPE20
FBBB*A004        LDY #HIGH FPE20
FBBD*20C966      JSR CONUPK
```

```
FBC0*20EAFD       JSR FPDIV
FBC3*204568       JSR MOVAF
FBC6*A9AA         LDA #LOW INT6029 ;0.6029
FBC8*A004         LDY #HIGH INT6029
FBCA*20DF67       JSR MOVFM
FBCD*20EAFD       JSR FPDIV
FBD0*A2F2         LDX #LOW FPM
FBD2*A004         LDY #HIGH FPM
FBD4*20D068       JSR MOVMF
FBD7*2061FD       JSR RCALC ;DISPLAY SOMEWHERE???

FBDA*             DAC105RA
FBDA*206BA3       JSR CLRDSP
FBDD*20ABA3       JSR DSPONC
FBE0*A920         LDA #$20
FBE2*8501         STA ADDR+1
FBE4*6400         STZ ADDR
FBE6*A9DE         LDA #LOW FPV
FBE8*A004         LDY #HIGH FPV
FBEA*206DFE       JSR FLTPRT
FBED*A921         LDA #$21
FBEF*8501         STA ADDR+1
FBF1*A9E3         LDA #LOW FPV2
FBF3*A004         LDY #HIGH FPV2
FBF5*206DFE       JSR FLTPRT
FBF8*A922         LDA #$22
FBFA*8501         STA ADDR+1
FBFC*A9F2         LDA #LOW FPM
FBFE*A004         LDY #HIGH FPM
FC00*206DFE       JSR FLTPRT
FC03*A923         LDA #$23
FC05*8501         STA ADDR+1
FC07*A9CA         LDA #LOW FPARG
FC09*A003         LDY #HIGH FPARG
FC0B*206DFE       JSR FLTPRT
FC0E*A924         LDA #$24
FC10*8501         STA ADDR+1
FC12*A9A2         LDA #LOW FPWIND
FC14*A004         LDY #HIGH FPWIND
FC16*206DFE       JSR FLTPRT
FC19*A925         LDA #$25
FC1B*8501         STA ADDR+1
FC1D*A9D9         LDA #LOW FPR
FC1F*A004         LDY #HIGH FPR
FC21*206DFE       JSR FLTPRT
FC24*2068BE       JSR BEEP
                  ;JSR DUMPDATA
FC27*A9FC         LDA #LOW M81  ;"MAIN MENU"
FC29*A042         LDY #HIGH M81
FC2B*20E7DA       JSR INVMSGC1

FC2E*             DAC105RB
FC2E*207CA5       JSR KEYIN ;^FOR NOW
FC31*C911         CMP #$11
FC33*D0F9         BNE DAC105RB
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```
FC35*4C4081       JMP MM

                  ;DAC 105 CALCULATION DONE


FC38*             LINREG ;RUNNING LINEAR REGRESSION
FC38*A97C         LDA #LOW ARGTMP ;X
FC3A*A003         LDY #HIGH ARGTMP
FC3C*20DF67       JSR MOVFM
FC3F*A963         LDA #LOW FACTMP ;Y
FC41*A003         LDY #HIGH FACTMP
FC43*206566       JSR FMULT
FC46*A901         LDA #LOW FPSUMXY
FC48*A005         LDY #HIGH FPSUMXY
FC4A*200465       JSR FADD
FC4D*A201         LDX #LOW FPSUMXY
FC4F*A005         LDY #HIGH FPSUMXY
FC51*200D68       JSR MOVMF

FC54*A97C         LDA #LOW ARGTMP ;X
FC56*A003         LDY #HIGH ARGTMP
FC58*20DF67       JSR MOVFM
FC5B*A9F7         LDA #LOW FPSUMX
FC5D*A004         LDY #HIGH FPSUMX
FC5F*200465       JSR FADD
FC62*A2F7         LDX #LOW FPSUMX
FC64*A004         LDY #HIGH FPSUMX
FC66*200D68       JSR MOVMF

FC69*A97C         LDA #LOW ARGTMP ;X
FC6B*A003         LDY #HIGH ARGTMP
FC6D*20DF67       JSR MOVFM
FC70*A97C         LDA #LOW ARGTMP
FC72*A003         LDY #HIGH ARGTMP
FC74*206566       JSR FMULT ;X^2
FC77*A906         LDA #LOW FPSUMXX
FC79*A005         LDY #HIGH FPSUMXX
FC7B*200465       JSR FADD
FC7E*A206         LDX #LOW FPSUMXX
FC80*A005         LDY #HIGH FPSUMXX
FC82*200D68       JSR MOVMF

FC85*A963         LDA #LOW FACTMP ;Y
FC87*A003         LDY #HIGH FACTMP
FC89*20DF67       JSR MOVFM
FC8C*A9FC         LDA #LOW FPSUMY
FC8E*A004         LDY #HIGH FPSUMY
FC90*200465       JSR FADD
FC93*A2FC         LDX #LOW FPSUMY
FC95*A004         LDY #HIGH FPSUMY
FC97*200D68       JSR MOVMF

FC9A*A963         LDA #LOW FACTMP ;Y
```

```
FC9C*A003       LDY #HIGH FACTMP
FC9E*20DF67     JSR MOVFM
FCA1*A963       LDA #LOW FACTMP
FCA3*A003       LDY #HIGH FACTMP
FCA5*206566     JSR FMULT
FCA8*A90B       LDA #LOW FPSUMYY
FCAA*A005       LDY #HIGH FPSUMYY
FCAC*200465     JSR FADD
FCAF*A20B       LDX #LOW FPSUMYY
FCB1*A005       LDY #HIGH FPSUMYY
FCB3*4C0D68     JMP MOVMF

FCB6*           ACALC ;CALCULATE "A"  (Y = AX + B)
FCB6*207565     JSR NORMAL ;NORMALIZE "N"
FCB9*A263       LDX #LOW FACTMP
FCBB*A003       LDY #HIGH FACTMP
FCBD*200D68     JSR MOVMF
FCC0*A9F7       LDA #LOW FPSUMX
FCC2*A004       LDY #HIGH FPSUMX
FCC4*20DF67     JSR MOVFM
FCC7*A9FC       LDA #LOW FPSUMY
FCC9*A004       LDY #HIGH FPSUMY
FCCB*206566     JSR FMULT
FCCE*204568     JSR MOVAF
FCD1*A963       LDA #LOW FACTMP ;N
FCD3*A003       LDY #HIGH FACTMP
FCD5*20DF67     JSR MOVFM
FCD8*20EAFD     JSR FPDIV
FCDB*A901       LDA #LOW FPSUMXY
FCDD*A005       LDY #HIGH FPSUMXY
FCDF*20ED64     JSR FSUB
FCE2*A272       LDX #LOW FACTMP3 ;STORE
FCE4*A003       LDY #HIGH FACTMP3
FCE6*200D68     JSR MOVMF

FCE9*A9F7       LDA #LOW FPSUMX
FCEB*A004       LDY #HIGH FPSUMX
FCED*20DF67     JSR MOVFM
FCF0*A9F7       LDA #LOW FPSUMX
FCF2*A004       LDY #HIGH FPSUMX
FCF4*206566     JSR FMULT
FCF7*204568     JSR MOVAF
FCFA*A963       LDA #LOW FACTMP ;N
FCFC*A003       LDY #HIGH FACTMP
FCFE*20DF67     JSR MOVFM
FD01*20EAFD     JSR FPDIV
FD04*A906       LDA #LOW FPSUMXX
FD06*A005       LDY #HIGH FPSUMXX
FD08*20ED64     JSR FSUB
FD0B*A277       LDX #LOW FACTMP4 ;STORE
FD0D*A003       LDY #HIGH FACTMP4
FD0F*200D68     JSR MOVMF
FD12*A972       LDA #LOW FACTMP3
FD14*A003       LDY #HIGH FACTMP3
FD16*20C966     JSR CONUPK
```

```
FD19*20EAFD      JSR FPDIV
FD1C*A2CF        LDX #LOW FPA ;STORE
FD1E*A004        LDY #HIGH FPA
FD20*4C0D68      JMP MOVMF

FD23*            BCALC ;CALCULATE "B"  (Y = AX + B)
FD23*A9FC        LDA #LOW FPSUMY
FD25*A004        LDY #HIGH FPSUMY
FD27*20C966      JSR CONUPK
FD2A*A963        LDA #LOW FACTMP ;N
FD2C*A003        LDY #HIGH FACTMP
FD2E*20DF67      JSR MOVFM
FD31*20EAFD      JSR FPDIV
FD34*A26D        LDX #LOW FACTMP2
FD36*A003        LDY #HIGH FACTMP2
FD38*200D68      JSR MOVMF
FD3B*A9F7        LDA #LOW FPSUMX
FD3D*A004        LDY #HIGH FPSUMX
FD3F*20C966      JSR CONUPK
FD42*A963        LDA #LOW FACTMP ;N
FD44*A003        LDY #HIGH FACTMP
FD46*20DF67      JSR MOVFM
FD49*20EAFD      JSR FPDIV
FD4C*A9CF        LDA #LOW FPA
FD4E*A004        LDY #HIGH FPA
FD50*206566      JSR FMULT
FD53*A96D        LDA #LOW FACTMP2
FD55*A003        LDY #HIGH FACTMP2
FD57*20ED64      JSR FSUB
FD5A*A2D4        LDX #LOW FPB ;STORE
FD5C*A004        LDY #HIGH FPB
FD5E*4C0D68      JMP MOVMF

FD61*            RCALC ;CALCULATE CORRELATION COEFFICIENT
FD61*A972        LDA #LOW FACTMP3
FD63*A003        LDY #HIGH FACTMP3
FD65*20DF67      JSR MOVFM
FD68*A972        LDA #LOW FACTMP3
FD6A*A003        LDY #HIGH FACTMP3
FD6C*206566      JSR FMULT
FD6F*A268        LDX #LOW FACTMP1 ;STORE
FD71*A003        LDY #HIGH FACTMP1
FD73*200D68      JSR MOVMF
FD76*A9FC        LDA #LOW FPSUMY
FD78*A004        LDY #HIGH FPSUMY
FD7A*20DF67      JSR MOVFM
FD7D*A9FC        LDA #LOW FPSUMY
FD7F*A004        LDY #HIGH FPSUMY
FD81*206566      JSR FMULT
FD84*20456B      JSR MOVAF
FD87*A963        LDA #LOW FACTMP ;N
FD89*A003        LDY #HIGH FACTMP
FD8B*20DF67      JSR MOVFM
FD8E*20EAFD      JSR FPDIV
FD91*A90B        LDA #LOW FPSUMYY
```

```
FD93*A005        LDY #HIGH FPSUMYY
FD95*20ED64      JSR FSUB

FD98*A977        LDA #LOW FACTMP4
FD9A*A003        LDY #HIGH FACTMP4
FD9C*206566      JSR FMULT
FD9F*A968        LDA #LOW FACTMP1
FDA1*A003        LDY #HIGH FACTMP1
FDA3*20C966      JSR CONVFK
FDA6*20EAFD      JSR FPDIV
FDA9*A2D9        LDX #LOW FPR ;STORE
FDAB*A004        LDY #HIGH FPR
FDAD*4C0D68      JMP MOVMF

FDB0*            LINREG20 ;CALCULATE Y AT 20 MPH
FDB0*A9AF        LDA #LOW INT20
FDB2*A064        LDY #HIGH INT20
FDB4*20DF67      JSR MOVFM
FDB7*A9CF        LDA #LOW FPA
FDB9*A004        LDY #HIGH FPA
FDBB*206566      JSR FMULT
FDBE*A9D4        LDA #LOW FPB
FDC0*A004        LDY #HIGH FPB
FDC2*4C0465      JMP FADD

FDC5*            RESCALVAL ;RESET CALIBRATION VALUES
FDC5*6428        STZ MCAND
FDC7*6429        STZ MCAND+1
FDC9*9CF704      STZ FPSUMX
FDCC*9CFC04      STZ FPSUMY
FDCF*9C0105      STZ FPSUMXY
FDD2*9C0605      STZ FPSUMXX
FDD5*9C0B05      STZ FPSUMYY
FDD8*9C4903      STZ HRTCNT
FDDB*60          RTS
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                    ;COPYRIGHT 1986 FRONTLINE TECHNOLOGY, INC.
AC43*               RIDCOR ;RIDE COURSE
AC43*206BBE         JSR BEEP
AC46*9C4403         STZ TIMTRLFLG
AC49*AD1403         LDA RIDLEVEL
AC4C*D005           BNE RIDCOR3
AC4E*A980           LDA #$80
AC50*8D4403         STA TIMTRLFLG ;IGNORE PACK POSITION

AC53*               RIDCOR3
AC53*20728D         JSR LDINITDAC
AC56*9C0A02         STZ STARTFLG
AC59*9C0B02         STZ EXPFLG
AC5C*2003C4         JSR MENU1
AC5F*20A3A5         JSR DSPCRS ;DISPLAY COURSE
AC62*206BC3         JSR PRTLEVEL
AC65*2C4403         BIT TIMTRLFLG ;TIME TRIAL?
AC68*3003           BMI *+5 ;YES, FORGET PACK POSITION
AC6A*2009EA         JSR MENU27
AC6D*200BC7         JSR MENU2SOFT
AC70*648E           STZ DIST
AC72*2088D6         JSR RESVAL
AC75*202EB3         JSR RIDCURS

AC78*               RIDCOR4
AC78*645F           STZ KEY
AC7A*20D3C2         JSR KEYIN1
AC7D*F0FB           BEQ *-3
AC7F*C911           CMP #$11 ;START
AC81*D003           BNE *+5
AC83*4CA4AC         JMP RIDCOR5
AC86*C912           CMP #$12 ;EXPAND SCREEN
AC88*D003           BNE *+5
AC8A*4C05B0         JMP RIDCOR6
AC8D*C913           CMP #$13 ;RESET VALUES
AC8F*D009           BNE RIDCOR4A
AC91*206BBE         JSR BEEP
AC94*2088D6         JSR RESVAL
AC97*4C53AC         JMP RIDCOR3

AC9A*               RIDCOR4A
AC9A*C914           CMP #$14 ;PREVIOUS MENU
AC9C*D0DA           BNE RIDCOR4 ;INVALID KEY
AC9E*2096C0         JSR CHRLD
ACA1*4CEF86         JMP RUN

ACA4*               RIDCOR5 ;START
ACA4*206BBE         JSR BEEP
ACA7*AD0A02         LDA STARTFLG
ACAA*F003           BEQ *+5 ;NEW ENTRY
ACAC*4CE8AC         JMP RIDCOR5BA
ACAF*2003C4         JSR MENU1 ;REWRITE
ACB2*A58E           LDA DIST
ACB4*48             PHA
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```
ACB5*20A3A5     JSR DSPCRS
ACB8*68         PLA
ACB9*858E       STA DIST
ACBB*202EE3     JSR RIDCURS
ACBE*20[illegible]   JSR PRTLEVEL
ACC1*2C4403     BIT TIMTRLFLG ;TIME TRIAL?
ACC4*3003       BMI *+5 ;YES
ACC6*207FEA     JSR MENU28 ;PACK POSITION WITHOUT NAMES
ACC9*2004C5     JSR MENU1ASOFT
ACCC*A980       LDA #$80 ;MAKE AVG IN CENTER
ACCE*8D4603     STA AVGHRT

ACD1*           RIDCOR5A1
ACD1*78         SEI
ACD2*20[illegible]   JSR RESVAL
ACD5*20C3BE     JSR UPDATE
ACD8*648E       STZ DIST
ACDA*202EE3     JSR RIDCURS
ACDD*A9FF       LDA #$FF
ACDF*8D0402     STA STARTFLG
ACE2*6473       STZ DGCNT1
ACE4*649E       STZ DISTLAST
ACE6*8013       BRA RIDCOR5BB

ACE8*           RIDCOR5BA
ACE8*A9FF       LDA #$FF ;INDICATE NOW RUNNING.
ACEA*8D0402     STA STARTFLG
ACED*2004C5     JSR MENU1ASOFT
ACF0*2C4403     BIT TIMTRLFLG
ACF3*3006       BMI *+8
ACF5*20BEEA     JSR MENU28CLR
ACF8*207FEA     JSR MENU28

ACFB*           RIDCOR5BB
ACFB*209FA8     JSR IRQENABLE ;ENABLE T1, CB1, CA1, CA2
ACFE*A909       LDA #9
AD00*8D4903     STA HRTCNT
AD03*9C0B02     STZ EXPFLG ;CLR EXPAND FLG

AD06*           RIDCOR5AA
AD06*A673       LDX DGCNT1
AD08*BD9B02     LDA GRDHEX,X ;GET GRADE
AD0B*8D4203     STA GRADE
AD0E*2019BA     JSR HEXASCSHRT
AD11*A569       LDA ASCI+6
AD13*8D0603     STA GRDASC+1
AD16*A56A       LDA ASCI+7
AD18*8D0703     STA GRDASC+2
AD1B*A673       LDX DGCNT1
AD1D*BDD702     LDA SIGNCX,X
AD20*8D0503     STA GRDASC
AD23*8D2002     STA SIGNN
AD26*C920       CMP #$20
AD28*F008       BEQ RIDCOR5A2
AD2A*A980       LDA #$80 ;MAKE GRADE NEGATIVE
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AD2C*0D4203      ORA GRADE
AD2F*8D4203      STA GRADE

AD32*            RIDCOR5A2
AD32*209A89      JSR GRADECALC
AD35*A964        LDA #100 ;5 SEC DELAY
AD37*85A6        STA TIMER5
AD39*9C6E05      STZ RANDISTSAVE ;0 RANDOM DISTANCE

AD3C*            RIDCOR5AB
AD3C*645F        STZ KEY
AD3E*4C9BAF      JMP RIDCOR5F ;GET PACK SPEED

AD41*            RIDCOR5A
AD41*8D6D03      STA FACTMP2
AD44*20D3C2      JSR KEYIN1
AD47*F03D        BEQ RIDCOR5B
AD49*C911        CMP #$11
AD4B*D003        BNE *+5
AD4D*4C7DB1      JMP RIDCOR8 ;STOP
AD50*2C0B02      BIT EXPFLG ;EXPAND?
AD53*301C        BMI RIDCOR5CC ;YES
AD55*C912        CMP #$12 ;EXPAND
AD57*D003        BNE *+5
AD59*4CB6B0      JMP RIDCOR6B
AD5C*C913        CMP #$13 ;PREVIOUS MENU
AD5E*D003        BNE *+5
AD60*4CAAB1      JMP RIDCOR9 ;BACK TO PREVIOUS MENU
AD63*C914        CMP #$14
AD65*D0D5        BNE RIDCOR5AB ;INVALID KEY
AD67*2068BE      JSR BEEP
AD6A*A204        LDX #4 ;ROW 4
AD6C*208892      JSR HRBEEPTOGGLEL
AD6F*80CB        BRA RIDCOR5AB

AD71*            RIDCOR5CC ;EXPAND MODE
AD71*C912        CMP #$12 ;PREVIOUS (NORMAL SCREEN) MENU
AD73*D003        BNE *+5
AD75*4CE9B1      JMP RIDCOR12
AD78*C913        CMP #$13
AD7A*D0C0        BNE RIDCOR5AB
AD7C*2068BE      JSR BEEP
AD7F*A203        LDX #3 ;ROW 3
AD81*208892      JSR HRBEEPTOGGLEL
AD84*80B6        BRA RIDCOR5AB

AD86*            RIDCOR5B

AD86*2062B7      JSR RPMCALC
AD89*20D1B7      JSR CADCALC
AD8C*204CB8      JSR HEARTCALC

AD8F*202B8D      JSR ADAVG

AD92*A5A4        LDA TIMER3
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```
AD94*F01A       BEQ RIDCOR5C
AD96*A5A3       LDA TIMER2
AD98*D003       BNE *+5
AD9A*4C22AE     JMP RIDCOR5D
AD9D*A5A7       LDA TIMER6
AD9F*D003       BNE *+5
ADA1*4CF2AF     JMP RIDCOR5H
ADA4*2C4403     BIT TIMTRLFLG ;0?
ADA7*3098       BMI RIDCOR5A ;YES, SKIP PACK POS
ADA9*A5A5       LDA TIMER4
ADAB*D094       BNE RIDCOR5A
ADAD*4C9BAF     JMP RIDCOR5F

ADB0*           RIDCOR5C
ADB0*A903       LDA #3
ADB2*85A4       STA TIMER3

ADB4*20E1B6     JSR DISTCALC
ADB7*38         SEC
ADB8*A58E       LDA DIST
ADBA*E59E       SBC DISTLAST ;GET DISTANCE SO FAR IN THIS SEGMENT
ADBC*A673       LDX DGCNT1
ADBE*DDB902     CMP DSTHEX,X
ADC1*D059       BNE RIDCOR5C2 ;OK, NOT THERE YET
ADC3*E673       INC DGCNT1
ADC5*9CDF03     STZ DGCNTFLG
ADC8*A673       LDX DGCNT1
ADCA*E472       CPX DGCNT
ADCC*D003       BNE *+5 ;OK, NOT COMPLETELY DONE
ADCE*4C0FB2     JMP RIDCOR14 ;^FOR NOW, STOP
ADD1*BD9B02     LDA GRDHEX,X
ADD4*8D4203     STA GRADE
ADD7*2019BA     JSR HEXASCSHRT
ADDA*A569       LDA ASCI+6
ADDC*8D0603     STA GRDASC+1
ADDF*A56A       LDA ASCI+7
ADE1*8D0703     STA GRDASC+2
ADE4*A673       LDX DGCNT1
ADE6*BDD702     LDA SIGNCX,X
ADE9*8D0503     STA GRDASC
ADEC*8D2002     STA SIGNN
ADEF*C920       CMP #$20
ADF1*F019       BEQ RIDCOR5C0
ADF3*AD4203     LDA GRADE ;MAKE NEGATIVE
ADF6*0980       ORA #$80
ADF8*8D4203     STA GRADE
ADFB*BDD602     LDA SIGNCX-1,X ;WAS LAST SEGMENT POSITIVE?
ADFE*C920       CMP #$20
AE00*D00A       BNE RIDCOR5C0 ;NO
AE02*A964       LDA #100 ;YES, LOAD 5 SEC DELAY
AE04*85A6       STA TIMER5
AE06*AD0602     LDA RANDIST
AE09*8D6B05     STA RANDISTSAVE

AE0C*           RIDCOR5C0
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```
AE0C*209A8F      JSR GRADECALC
AE0F*20A5AF      JSR RANDISTCALC

AE12*            RIDCOR5C1
AE12*18          CLC
AE13*A6T3        LDX DGCNT1
AE15*BDE802      LDA DSTHEX-1,X ;ADD PREVIOUS DISTANCE
AE18*65FE        ADC DISTLAST
AE1A*859E        STA DISTLAST

AE1C*            RIDCOR5C2
AE1C*202EB3      JSR RIDCURS
AE1F*4C41AD      JMP RIDCOR5A

AE22*            RIDCOR5D
AE22*A5A2        LDA TIMER1
AE24*85A3        STA TIMER2
AE26*20C3BE      JSR UPDATE
AE29*2C4403      BIT TIMTRLFLG ;0?
AE2C*1003        BPL *+5
AE2E*4C41AD      JMP RIDCOR5A ;YES, SKIP PACK POSITION

AE31*            RIDCOR5D0

AE31*18          CLC
AE32*A5A6        LDA TIMER5 ;DELAY STILL ON?
AE34*F008        BEQ RIDCOR5D0A ;NO
AE36*AD0202      LDA PHANTDIST+2
AE39*6D6B05      ADC RANDISTSAVE
AE3C*8006        BRA RIDCOR5D0B

AE3E*            RIDCOR5D0A
AE3E*AD0202      LDA PHANTDIST+2
AE41*6D0602      ADC RANDIST

AE44*            RIDCOR5D0B
AE44*8D0202      STA PHANTDIST+2
AE47*AD0102      LDA PHANTDIST+1
AE4A*6900        ADC #0
AE4C*8D0102      STA PHANTDIST+1
AE4F*AD0002      LDA PHANTDIST
AE52*6900        ADC #0
AE54*8D0002      STA PHANTDIST
AE57*9C0802      STZ DISTDIR ;MAKE POSITIVE TO START
AE5A*38          SEC
AE5B*78          SEI
AE5C*AD5D03      LDA RPMDIST+2
AE5F*ED0202      SBC PHANTDIST+2
AE62*8D0502      STA DISTDIFF+2
AE65*AD5C03      LDA RPMDIST+1
AE68*ED0102      SBC PHANTDIST+1
AE6B*8D0402      STA DISTDIFF+1
AE6E*AD5B03      LDA RPMDIST
AE71*ED0002      SBC PHANTDIST
AE74*8D0302      STA DISTDIFF
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```
AE77*58         CLI
AE78*B003       BCS *+5
AE7A*4C0CAF     JMP RIDCOR5D5 ;NEGATIVE

AE7D*           RIDCOR5D1
AE7D*38         SEC
AE7E*AD0502     LDA DISTDIFF+2
AE81*E928       SBC #$28 ;1320 FEET
AE83*AD0402     LDA DISTDIFF+1
AE86*E905       SBC #5
AE88*AD0302     LDA DISTDIFF
AE8B*E900       SBC #0
AE8D*9005       BCC RIDCOR5D1A
AE8F*A92D       LDA #45
AE91*4CB7B2     JMP PACKDISP0 ;FULL WINDLOAD

AE94*           RIDCOR5D1A
AE94*38         SEC
AE95*AD0502     LDA DISTDIFF+2
AE98*E978       SBC #120 ;120 FEET
AE9A*AD0402     LDA DISTDIFF+1
AE9D*E900       SBC #0
AE9F*AD0302     LDA DISTDIFF
AEA2*E900       SBC #0
AEA4*9005       BCC RIDCOR5D2
AEA6*A92B       LDA #43
AEA8*4CB7B2     JMP PACKDISP0 ;FULL WINDLOAD

AEAB*           RIDCOR5D2
AEAB*38         SEC
AEAC*AD0502     LDA DISTDIFF+2
AEAF*E964       SBC #100 ;100 FEET
AEB1*AD0402     LDA DISTDIFF+1
AEB4*E900       SBC #0
AEB6*AD0302     LDA DISTDIFF
AEB9*E900       SBC #0
AEBB*9005       BCC RIDCOR5D2A
AEBD*A927       LDA #39
AEBF*4CBCB2     JMP PACKDISP

AEC2*           RIDCOR5D2A
AEC2*38         SEC
AEC3*AD0502     LDA DISTDIFF+2
AEC6*E950       SBC #80 ;80 FEET
AEC8*AD0402     LDA DISTDIFF+1
AECB*E900       SBC #0
AECD*AD0302     LDA DISTDIFF
AED0*E900       SBC #0
AED2*9005       BCC RIDCOR5D3
AED4*A926       LDA #38
AED6*4CBCB2     JMP PACKDISP

AED9*           RIDCOR5D3
AED9*38         SEC
AEDA*AD0502     LDA DISTDIFF+2
```

```
AEDD*E93C        SBC #60 ;60 FEET
AEDF*AD0402      LDA DISTDIFF+1
AEE2*E900        SBC #0
AEE4*AD0302      LDA DISTDIFF
AEE7*E900        SBC #0
AEE9*9005        BCC RIDCOR5D3A
AEEB*A925        LDA #37
AEED*4CBCB2      JMP PACKDISP

AEF0*            RIDCOR5D3A
AEF0*38          SEC
AEF1*AD0502      LDA DISTDIFF+2
AEF4*E928        SBC #40 ;40 FEET
AEF6*AD0402      LDA DISTDIFF+1
AEF9*E900        SBC #0
AEFB*AD0302      LDA DISTDIFF
AEFE*E900        SBC #0
AF00*9005        BCC RIDCOR5D4
AF02*A924        LDA #36
AF04*4CBCB2      JMP PACKDISP

AF07*            RIDCOR5D4
AF07*A923        LDA #35 ;LESS THAN 40 FEET
AF09*4CBCB2      JMP PACKDISP

AF0C*            RIDCOR5D5
AF0C*38          SEC
AF0D*AD0502      LDA DISTDIFF+2
AF10*E9D8        SBC #$D8 ;-1320 FEET
AF12*AD0402      LDA DISTDIFF+1
AF15*E9FA        SBC #$FA
AF17*AD0302      LDA DISTDIFF
AF1A*E9FF        SBC #$FF
AF1C*B005        BCS RIDCOR5D5A
AF1E*A919        LDA #25 ;>1320 FEET OFF
AF20*4CB7B2      JMP PACKDISP0 ;FULL WINDLOAD

AF23*            RIDCOR5D5A
AF23*38          SEC
AF24*AD0502      LDA DISTDIFF+2
AF27*E988        SBC #$88 ;-120 FEET
AF29*AD0402      LDA DISTDIFF+1
AF2C*E9FF        SBC #$FF
AF2E*AD0302      LDA DISTDIFF
AF31*E9FF        SBC #$FF
AF33*B005        BCS RIDCOR5D6
AF35*A91B        LDA #27 ;>120 FEET OFF
AF37*4CB7B2      JMP PACKDISP0 ;FULL WINDLOAD

AF3A*            RIDCOR5D6
AF3A*38          SEC
AF3B*AD0502      LDA DISTDIFF+2
AF3E*E99C        SBC #$9C ;-100 FEET
AF40*AD0402      LDA DISTDIFF+1
AF43*E9FF        SBC #$FF
```

```
AF45*AD0302       LDA DISTDIFF
AF48*E9FF         SBC #$FF
AF4A*B005         BCS RIDCOR5D6A
AF4C*A91F         LDA #31
AF4E*4CBCB2       JMP PACKDISP

AF51*             RIDCOR5D6A
AF51*38           SEC
AF52*AD0502       LDA DISTDIFF+2
AF55*E9B0         SBC #$B0 ;-80 FEET
AF57*AD0402       LDA DISTDIFF+1
AF5A*E9FF         SBC #$FF
AF5C*AD0302       LDA DISTDIFF
AF5F*E9FF         SBC #$FF
AF61*B005         BCS RIDCOR5D7
AF63*A920         LDA #32
AF65*4CBCB2       JMP PACKDISP

AF68*             RIDCOR5D7
AF68*38           SEC
AF69*AD0502       LDA DISTDIFF+2
AF6C*E9C4         SBC #$C4 ;-60 FEET
AF6E*AD0402       LDA DISTDIFF+1
AF71*E9FF         SBC #$FF
AF73*AD0302       LDA DISTDIFF
AF76*E9FF         SBC #$FF
AF78*B005         BCS RIDCOR5D7A
AF7A*A921         LDA #33
AF7C*4CBCB2       JMP PACKDISP

AF7F*             RIDCOR5D7A
AF7F*38           SEC
AF80*AD0502       LDA DISTDIFF+2
AF83*E9D8         SBC #$D8 ;-40 FEET
AF85*AD0402       LDA DISTDIFF+1
AF88*E9FF         SBC #$FF
AF8A*AD0302       LDA DISTDIFF
AF8D*E9FF         SBC #$FF
AF8F*B005         BCS RIDCOR5D8
AF91*A922         LDA #34
AF93*4CBCB2       JMP PACKDISP

AF96*             RIDCOR5D8
AF96*A923         LDA #35 ;LESS THAN 40 FEET BEHIND
AF98*4CBCB2       JMP PACKDISP

AF9B*             RIDCOR5F ;CALCULATE PACK POSITION
AF9B*A917         LDA #23
AF9D*85A5         STA TIMER4
AF9F*20A5AF       JSR RANDISTCALC
AFA2*4C41AD       JMP RIDCOR5A

AFA5*             RANDISTCALC
AFA5*AD5D03       LDA RPMDIST+2
AFA8*2907         AND #7
```

```
AFAA*0A         ASL A ;*2
AFAB*AA         TAX
AFAC*BDE45B     LDA MULTADDF,X
AFAF*8570       STA INDEX4
AFB1*BDE55B     LDA MULTADDR+1,X
AFB4*8571       STA INDEX4+1
AFB6*2033F4     JSR RDYFAC
AFB9*AD1403     LDA RIDLEVEL
AFBC*38         SEC
AFBD*E901       SBC #1 ;MAKE 0-8
AFBF*0A         ASL A ;*16 (FOR 16 GRADES)
AFC0*0A         ASL A
AFC1*0A         ASL A
AFC2*0A         ASL A
AFC3*8585       STA ASAVE3
AFC5*AD4203     LDA GRADE
AFC8*297F       AND #$7F
AFCA*18         CLC
AFCB*6585       ADC ASAVE3
AFCD*AA         TAX
AFCE*AD2002     LDA SIGNN
AFD1*C92D       CMP #'-' ;NEGATIVE?
AFD3*F018       BEQ RIDCOR5G2

AFD5*           RIDCOR5G
AFD5*BDE25B     LDA BASEDISTP,X

AFD8*           RIDCOR5G1
AFD8*85DA       STA FACLO
AFDA*209965     JSR NORMAL
AFDD*A570       LDA INDEX4
AFDF*A471       LDY INDEX4+1
AFE1*208966     JSR FMULT
AFE4*20F868     JSR QINT
AFE7*A5DA       LDA FACLO
AFE9*8D0602     STA RANDIST
AFEC*60         RTS


AFED*           RIDCOR5G2 ;NEGATIVE SLOPE
AFED*BD725C     LDA BASEDISTN,X
AFF0*80E6       BRA RIDCOR5G1

AFF2*           RIDCOR5H
AFF2*A906       LDA #6
AFF4*85A7       STA TIMER6

AFF6*20078A     JSR SPEEDDIV10
AFF9*20BD89     JSR WINDCALC
AFFC*206E89     JSR POWERCALC
AFFF*20198A     JSR DACCALC

B002*4C41AD     JMP RIDCOR5A
```

```
B005*               RIDCOR6 ;EXPAND
B005*20[illegible]EE       JSR BEEP
B008*2003C4         JSR MENU1
B00B*20[illegible]E[illegible]3       JSR PRTLEVEL
B00E*A9FF           LDA #$FF
B010*8D0502         STA EXPFLG

B013*AD0A02         LDA STARTFLG
B016*F003           BEQ *+5 ;NEW ENTRY
B018*4C56B0         JMP RIDCOR6A0
B01B*78             SEI
B01C*2088D6         JSR RESVAL
B01F*20C3BE         JSR UPDATE
B022*58             CLI ;^
B023*640E           STZ PNT7 ;ARTIFICIALLY LOAD PNT7 IN MIDDLE OF SCREEN FOR EL-[illegible]
B025*A92C           LDA #$2C ;30
B027*850F           STA PNT7+1
B029*20A3A5         JSR DSPCRS
B02C*648E           STZ DIST
B02E*6499           STZ DIST5
B030*58             CLI
B031*202EB3         JSR RIDCURS
B034*A9FF           LDA #$FF
B036*8D0A02         STA STARTFLG
B039*6473           STZ DGCNT1
B03B*9CDF03         STZ DGCNTFLG
B03E*649E           STZ DISTLAST
B040*AD9B02         LDA GRDHEX ;GET 1ST GRADE
B043*8D4203         STA GRADE
B046*2019BA         JSR HEXASCSHRT
B049*A569           LDA ASCI+6
B04B*8D0603         STA GRDASC+1
B04E*A56A           LDA ASCI+7
B050*8D0703         STA GRDASC+2
B053*4C5EB0         JMP RIDCOR6A1

B056*               RIDCOR6A0
B056*20D8B0         JSR EXPCALC
B059*A9FF           LDA #$FF
B05B*8D0A02         STA STARTFLG

B05E*               RIDCOR6A1
B05E*2C4403         BIT TIMTRLFLG ;TIME TRIAL?
B061*3006           BMI *+8 ;YES
B063*20BEEA         JSR MENU28CLR
B066*2009EA         JSR MENU27

B069*               RIDCOR6AA
B069*2083C5         JSR MENU1HSOFT
                    ;^STZ MMFLG ;FOR SCROLL

B06C*               RIDCOR6A
B06C*645F           STZ KEY
B06E*20D3C2         JSR KEYIN1
B071*F0FB           BEQ *-3
```

SUBSTITUTE SHEET

```
B073*C911        CMP #$11 ;START
B075*D003        BNE *+5
B077*4CC0B1      JMP RIDCOR11
B07A*C913        CMP #$13 ;RESET VALUES
B07C*D003        BNE *+5
B07E*4CB0B0      JMP RIDCOR6AT
B081*C912        CMP #$12 ;PREVIOUS MENU
B083*D003        BNE *+5 ;^TEST
                 ;BNE RIDCOR6A ;INVALID KEY
B085*4C32B1      JMP RIDCOR7

B088*C914        CMP #$14
B08A*D0E0        BNE RIDCOR6A
                 ;^TEST

B08C*206BBE      JSR BEEP
B08F*2CC205      BIT MMFLG ;ANY COURSE LEFT?
B092*1005        BPL RIDCOR6AZ ;YES
B094*9CC205      STZ MMFLG ;RESET TO 0
B097*8017        BRA RIDCOR6AT ;RESET AND RTN

B099*            RIDCOR6AZ
B099*2003C4      JSR MENU1
B09C*2083C5      JSR MENU1HSOFT
B09F*20B5A5      JSR DSPCRS01
                 ;BCS RIDCOR6AX ;NOT DONE YET
                 ;LDA #$FF ;FINISHED
                 ;STA MMFLG

B0A2*            RIDCOR6AX
B0A2*206BC3      JSR PRTLEVEL
                 ;JSR TEST
B0A5*2C4403      BIT TIMTRLFLG ;TIME TRIAL?
B0A8*3003        BMI *+5 ;YES
B0AA*2009EA      JSR MENU27
B0AD*4C6CB0      JMP RIDCOR6A



B0B0*            RIDCOR6AT ;RESET VALUES
B0B0*2088D6      JSR RESVAL
B0B3*4C05B0      JMP RIDCOR6

B0B6*            RIDCOR6B ;EXPAND WHILE RUNNING
B0B6*206BBE      JSR BEEP
B0B9*2003C4      JSR MENU1
B0BC*2028C5      JSR MENU1BSOFT
B0BF*206BC3      JSR PRTLEVEL
B0C2*A9FF        LDA #$FF
B0C4*8D0B02      STA EXPFLG
B0C7*20D8B0      JSR. EXPCALC
B0CA*2C4403      BIT TIMTRLFLG ;TIME TRIAL?
B0CD*3006        BMI *+8 ;YES
B0CF*20BEEA      JSR MENU28CLR
```

```
B0D2*207FEA       JSR MENU28
B0D5*4C06AD       JMP RIDCOR5AA

B0D8*             EXPCALC
B0D8*2033F4       JSR RDYFAC
B0DB*A58E         LDA DIST
B0DD*85DA         STA FACLO
B0DF*209965       JSR NORMAL
B0E2*204367       JSR MUL10
B0E5*A21E         LDX #LOW DIST6
B0E7*A004         LDY #HIGH DIST6
B0E9*203166       JSR MOVMF
B0EC*A200         LDX #0
B0EE*9C2202       STZ DSTTOT

B0F1*             EXPCALCB
B0F1*18           CLC
B0F2*BDE902       LDA DSTHEX,X
B0F5*6D2202       ADC DSTTOT
B0F8*8D2202       STA DSTTOT
B0FB*E473         CPX DGCNT1
B0FD*F003         BEQ EXPCALCC
B0FF*E8           INX
B100*D0EF         BNE EXPCALCB ;ALWAYS

B102*             EXPCALCC
B102*869F         STX BYTDIST
B104*38           SEC
B105*AD2202       LDA DSTTOT
B108*E58E         SBC DIST
B10A*8593         STA DIST3
B10C*A204         LDX #4

B10E*             EXPCALCD
B10E*B599         LDA DIST5,X
B110*9594         STA DIST4,X
B112*CA           DEX
B113*10F9         BPL EXPCALCD

B115*A58E         LDA DIST
B117*48           PHA
B118*20B5A5       JSR DSPCRS01
B11B*68           PLA
B11C*858E         STA DIST
B11E*9C1502       STZ LAPNR
B121*6488         STZ NRBYT
B123*640E         STZ PNT7 ;ARTIFICIALLY LOAD PNT7 IN MIDDLE OF SCREEN FOR BLKCURS
B125*A930         LDA #$30
B127*850F         STA PNT7+1
B129*A673         LDX DGCNT1
B12B*BD0004       LDA SEGADDR+1,X

B12E*2087B3       JSR RIDCURS0
B131*60           RTS
```

```
B132*                RIDCOR7 ;COMPRESS DISPLAY
B132*2068BE          JSR BEEP
B135*9C0B02          STZ EXPFLG ;CLR EXPAND FLAG
B138*A58E            LDA DIST ;SAVE DIST
B13A*48              PHA
B13B*2003C4          JSR MENU1
B13E*20A3A5          JSR DSPCRS
B141*2065C3          JSR PRTLEVEL
B144*200EC7          JSR MENU2SOFT
B147*68              PLA
B148*858E            STA DIST
B14A*2058B1          JSR NORMCALC

B14D*2C4403          BIT TIMTRLFLG ;TIME TRIAL?
B150*3003            BMI *+5 ;YES
B152*2009EA          JSR MENU27
B155*4C76AC          JMP RIDCOR4 ;FOR NOW

B158*                NORMCALC
B158*9C2202          STZ DSTTOT
B15B*6488            STZ NRBYT
B15D*A200            LDX #0

B15F*                NORMCALCA
B15F*E473            CPX DGCNT1
B161*F00D            BEQ NORMCALCB
B163*18              CLC
B164*BDB902          LDA DSTHEX,X
B167*6D2202          ADC DSTTOT
B16A*8D2202          STA DSTTOT
B16D*E8              INX
B16E*D0EF            BNE NORMCALCA ;ALWAYS

B170*                NORMCALCB
B170*A673            LDX DGCNT1
B172*F005            BEQ NORMCALCC ;0, SKIP REST
B174*BDFF03          LDA SEGADDR,X
B177*8588            STA NRBYT

B179*                NORMCALCC
B179*20F5B3          JSR RIDCURSB
B17C*60              RTS

B17D*                RIDCOR8 ;STOP
B17D*20B4C3          JSR STOPVAL ;PUT SOME VALUES TO 0
B180*EE0A02          INC STARTFLG ;PUT BACK TO $01
B183*2068BE          JSR BEEP
B186*2C0B02          BIT EXPFLG
B189*100E            BPL RIDCOR8A
B18B*2C4403          BIT TIMTRLFLG
B18E*3006            BMI *+8
B190*20BEEA          JSR MENU28CLR
B193*2009EA          JSR MENU27
B196*4C69B0          JMP RIDCOR6AA
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```
B199*               RIDCOR8A
B199*2C4403         BIT TIMTRLFLG
B19C*3006           BMI *+8
B19E*20BEEA         JSR MENU28CLR
B1A1*209FEA         JSR MENU27
B1A4*2028C7         JSR MENU2SOFT
B1A7*4C78AC         JMP RIDCOR4

B1AA*               RIDCOR9 ;BACK TO PREVIOUS MENU
B1AA*A953           LDA #$53 ;T1, CA1, CA2, CB1 IRQ OFF
B1AC*8D8E7F         STA $7F8E
B1AF*20F6C0         JSR CHRLD
B1B2*4CEF86         JMP RUN

B1B5*               RIDCOR10
B1B5*A953           LDA #$53 ;CA1, CA2, CB1 IRQ OFF
B1B7*8D8E7F         STA $7F8E
B1BA*2083C5         JSR MENU1HSOFT
B1BD*4C6CB0         JMP RIDCOR6A

B1C0*               RIDCOR11
B1C0*209FA8         JSR IRQENABLE
B1C3*AD0A02         LDA STARTFLG ;PREVIOUSLY RUNNING?
B1C6*F019           BEQ RIDCOR11A ;NO
B1C8*A9FF           LDA #$FF
B1CA*8D0A02         STA STARTFLG ;INDICATE NOW RUNNING
B1CD*2069BE         JSR BEEP
B1D0*2028C5         JSR MENU1BSOFT
B1D3*2C4403         BIT TIMTRLFLG
B1D6*3006           BMI *+8
B1D8*20BEEA         JSR MENU28CLR
B1DB*207FEA         JSR MENU28
B1DE*4C06AD         JMP RIDCOR5AA

B1E1*               RIDCOR11A
B1E1*A9FF           LDA #$FF
B1E3*8D0A02         STA STARTFLG
B1E6*4CB6B0         JMP RIDCOR6B

B1E9*               RIDCOR12 ;BACK TO NORMAL DISPLAY
B1E9*2068BE         JSR BEEP
B1EC*9C0B02         STZ EXPFLG ;CLEAR EXPAND FLAG
B1EF*2003C4         JSR MENU1
B1F2*2004C5         JSR MENU1ASOFT
B1F5*206BC3         JSR PRTLEVEL
B1F8*A58E           LDA DIST ;SAVE DIST
B1FA*48             PHA
B1FB*20A3A5         JSR DSPCRS
B1FE*68             PLA
B1FF*858E           STA DIST
B201*2058B1         JSR NORMCALC
B204*2C4403         BIT TIMTRLFLG ;TIME TRIAL?
B207*3003           BMI *+5 ;YES
B209*207FEA         JSR MENU28
B20C*4CFBAC         JMP RIDCOR5BB
```

```
B20F*                RIDCOR14 ;STOP AT END OF COURSE
B20F*2068BE          JSR BEEP
B212*20B4C3          JSR STOPVAL ;PUT SOME VALUES TO 0
B215*20C3BE          JSR UPDATE
B218*2045C5          JSR MENU10SOFT ;ERASE SOFTKEYS
B21B*2C0B02          BIT EXPFLG ;EXPAND?
B21E*1006            BPL RIDCOR14B ;NO
B220*2083C5          JSR MENU1HSOFT
B223*4C29B2          JMP RIDCOR14C

B226*                RIDCOR14B
B226*200BC7          JSR MENU2SOFT

B229*                RIDCOR14C
B229*2C4403          BIT TIMTRLFLG
B22C*3006            BMI *+8
B22E*20BEEA          JSR MENU28CLR ;CLR MENU28
B231*2009EA          JSR MENU27

B234*                RIDCOR14D
B234*645F            STZ KEY
B236*20D3C2          JSR KEYIN1
B239*F0FB            BEQ *-3
B23B*C911            CMP #$11 ;START
B23D*D003            BNE *+5
B23F*4CA6B2          JMP RIDCOR15
B242*2C0B02          BIT EXPFLG ;EXPAND?
B245*3027            BMI RIDCOR14F ;YES
B247*C912            CMP #$12 ;EXPAND SCREEN
B249*D003            BNE *+5
B24B*4C05B0          JMP RIDCOR6
B24E*C913            CMP #$13 ;RESET VALUES
B250*F007            BEQ RIDCOR14E
B252*C914            CMP #$14 ;PREVIOUS MENU
B254*D0DE            BNE RIDCOR14D
B256*4CAAB1          JMP RIDCOR9

B259*                RIDCOR14E ;RESET VALUES
B259*2068BE          JSR BEEP
B25C*9C0A02          STZ STARTFLG
B25F*205BB5          JSR BLKCURS
B262*2088D6          JSR RESVAL
B265*20C3BE          JSR UPDATE
B268*202EB3          JSR RIDCURS
B26B*4C34B2          JMP RIDCOR14D

B26E*                RIDCOR14F
B26E*C913            CMP #$13 ;RESET VALUES
B270*D003            BNE *+5
B272*4C7FB2          JMP RIDCOR14G
B275*C912            CMP #$12 ;PREVIOUS MENU
B277*D0BB            BNE RIDCOR14D ;INVALID KEY
B279*2068BE          JSR BEEP
B27C*4C53AC          JMP RIDCOR3
```

```
B27F*                RIDCOR14G
B27F*2068BE          JSR BEEP
B282*2088D6          JSR RESVAL
B285*9C0A02          STZ STARTFLG
B288*2003C4          JSR MENU1
B28B*20A3A5          JSR DSPCRS
B28E*206BC3          JSR PRTLEVEL
B291*648E            STZ DIST
B293*6499            STZ DIST5
B295*202EE3          JSR RIDCURS
B298*2083C5          JSR MENU1HSOFT
B29B*2C4403          BIT TIMTRLFLG
B29E*3003            BMI *+5
B2A0*2009EA          JSR MENU27
B2A3*4C34B2          JMP RIDCOR14D

B2A6*                RIDCOR15 ;START AFTER COURSE ENDED
                     ;JSR BEEP
B2A6*9C0A02          STZ STARTFLG
B2A9*2088D6          JSR RESVAL
B2AC*2C0B02          BIT EXPFLG ;EXPAND?
B2AF*3003            BMI *+5 ;YES
B2B1*4CA4AC          JMP RIDCOR5
B2B4*4CC0B1          JMP RIDCOR11

B2B7*                PACKDISP0 ;FULL WINDLOAD
B2B7*9C6905          STZ WINDLOADFLG
B2BA*8005            BRA PACKDISP00

B2BC*                PACKDISP ;DISPLAY IN PACK POSITION
B2BC*A2FF            LDX #$FF
B2BE*8E6905          STX WINDLOADFLG

B2C1*                PACKDISP00
B2C1*48              PHA ;SAVE POSITION
B2C2*A510            LDA PNT8
B2C4*8500            STA ADDR
B2C6*A511            LDA PNT8+1
B2C8*8501            STA ADDR+1
B2CA*A205            LDX #5
B2CC*A000            LDY #0

B2CE*                PACKDISP1
B2CE*A900            LDA #0 ;CLEAR EXISTING PACK
B2D0*9100            STA (ADDR),Y
B2D2*CA              DEX
B2D3*F005            BEQ PACKDISP2
B2D5*207FA7          JSR ADD40
B2D8*80F4            BRA PACKDISP1

B2DA*                PACKDISP2
B2DA*68              PLA ;GET POSITION BACK
B2DB*8500            STA ADDR
B2DD*8510            STA PNT8
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```
B2DF*A920       LDA #$20
B2E1*8501       STA ADDR+1
B2E3*A205       LDX #5
B2E5*A000       LDY #0

B2E7*           PACKDISP3
B2E7*A9FF       LDA #$FF
B2E9*9100       STA (ADDR),Y
B2EB*CA         DEX
B2EC*F005       BEQ PACKDISP4
B2EE*207FA7     JSR ADD40
B2F1*80F4       BRA PACKDISP3

B2F3*           PACKDISP4
B2F3*4C41AD     JMP RIDCOR5A
```

```
                ;COPYRIGHT 1986 FRONTLINE TECHNOLOGY, INC.
896E            POWERCALC ;CALCULATE POWER
896E A99D       LDA #LOW FPGRADE
8970 A004       LDY #HIGH FPGRADE
8972 20DF67     JSR MOVFM

8975 A9A2       LDA #LOW FPWIND
8977 A004       LDY #HIGH FPWIND
8979 200465     JSR FADD

897C            POWERCALC0
897C 245B       BIT FACSGN ;NEGATIVE?
897E 1004       BPL POWERCALC1
8980 9CCF03     STZ FPPOWER ;YES, MAKE 0
8983 60         RTS

8984            POWERCALC1
8984 A98E       LDA #LOW FPSPEED
8986 A004       LDY #HIGH FPSPEED
8988 206566     JSR FMULT
898B A9F1       LDA #LOW INT0447 ;0.0447 (MPH TO METERS/SEC, DIV BY 10)
898D A063       LDY #HIGH INT0447
898F 206566     JSR FMULT
8992 A2CF       LDX #LOW FPPOWER
8994 A003       LDY #HIGH FPPOWER
8996 200D68     JSR MOVMF
8999 60         RTS

899A            GRADECALC ;CALCULATE GRADE POWER
899A AD4203     LDA GRADE
899D 207568     JSR FLOAT
89A0 A9D3       LDA #LOW INT4448
89A2 A063       LDY #HIGH INT4448
89A4 206566     JSR FMULT
89A7 A9CE       LDA #LOW INT0178
89A9 A063       LDY #HIGH INT0178
89AB 200465     JSR FADD
89AE A998       LDA #LOW FPWEIGHT
89B0 A004       LDY #HIGH FPWEIGHT
89B2 206566     JSR FMULT
89B5 A29D       LDX #LOW FPGRADE
89B7 A004       LDY #HIGH FPGRADE
89B9 200D68     JSR MOVMF
89BC 60         RTS

89BD            WINDCALC
89BD A998       LDA #LOW FPWEIGHT
89BF A004       LDY #HIGH FPWEIGHT
89C1 20DF67     JSR MOVFM
89C4 A9E7       LDA #LOW INT205 ;0.0002055556
89C6 A063       LDY #HIGH INT205
89C8 206566     JSR FMULT
89CB A9E2       LDA #LOW INT226 ;0.002266667
89CD A063       LDY #HIGH INT226
```

```
89CF 2004E5        JSR FADD
89D2 A263          LDX #LOW FACTMP
89D4 A003          LDY #HIGH FACTMP
89D6 200D68        JSR MOVMF
89D9 A993          LDA #LOW FPSPEED10
89DB A004          LDY #HIGH FPSPEED10
89DD 20C966        JSR CONUPK
89E0 A9EC          LDA #LOW INT2 ;^2
89E2 A063          LDY #HIGH INT2
89E4 20DF67        JSR MOVFM
89E7 20926B        JSR FPWRT
89EA A963          LDA #LOW FACTMP
89EC A003          LDY #HIGH FACTMP
89EE 206566        JSR FMULT
89F1 AD6905        LDA WINDLOADFLG
89F4 D008          BNE WINDCALC2

89F6               WINDCALC1
89F6 A2A2          LDX #LOW FPWIND
89F8 A004          LDY #HIGH FPWIND
89FA 200D68        JSR MOVMF
89FD 60            RTS

89FE               WINDCALC2
89FE A90F          LDA #LOW INTPT7 ;0.70
8A00 A064          LDY #HIGH INTPT7
8A02 206566        JSR FMULT
8A05 80EF          BRA WINDCALC1

8A07               SPEEDDIV10
8A07 A98E          LDA #LOW FPSPEED
8A09 A004          LDY #HIGH FPSPEED
8A0B 20DF67        JSR MOVFM
8A0E 203B67        JSR DIV10
8A11 A293          LDX #LOW FPSPEED10
8A13 A004          LDY #HIGH FPSPEED10
8A15 200D68        JSR MOVMF
8A18 60            RTS

8A19               PAGE
```

```
8A19            DACCALC ;CALCULATE DAC VALUE AND LOAD
8A19 2033F4     JSR RDYFAC
8A1C AD4A04     LDA ADTOT+1
8A1F 85DA       STA FACLO
8A21 AD4904     LDA ADTOT
8A24 85D9       STA FACMO
8A26 207565     JSR NORMAL
8A29 A9C4       LDA #LOW INT9765 ;.009765625
8A2B A063       LDY #HIGH INT9765
8A2D 206566     JSR FMULT ;NORMALIZE TO VOLTS
8A30 A2C5       LDX #LOW FFACC
8A32 A003       LDY #HIGH FFACC
8A34 200D68     JSR MOVMF
8A37 A9C5       LDA #LOW FPACC
8A39 A003       LDY #HIGH FPACC
8A3B 206566     JSR FMULT ;^2
8A3E A993       LDA #LOW FPSPEED10 ;SPEED/10
8A40 A004       LDY #HIGH FPSPEED10
8A42 206566     JSR FMULT
8A45 A9F6       LDA #LOW INT1408 ;14.08
8A47 A063       LDY #HIGH INT1408
8A49 206566     JSR FMULT
8A4C A263       LDX #LOW FACTMP
8A4E A003       LDY #HIGH FACTMP
8A50 200D68     JSR MOVMF ;SAVE
8A53 A956       LDA #LOW INT1
8A55 A063       LDY #HIGH INT1
8A57 20C966     JSR CONUPK
8A5A A993       LDA #LOW FPSPEED10
8A5C A004       LDY #HIGH FPSPEED10
8A5E 20DF67     JSR MOVFM
8A61 20EAFD     JSR FPDIV ;1/V
8A64 A937       LDA #LOW INTE
8A66 A064       LDY #HIGH INTE
8A68 20C966     JSR CONUPK
8A6B A5D6       LDA FACEXP ;GET READY FOR FPWRT
8A6D 20926B     JSR FPWRT

8A70 A9FB       LDA #LOW INT12832 ;0.12832
8A72 A063       LDY #HIGH INT12832
8A74 206566     JSR FMULT
8A77 204568     JSR MOVAF
8A7A A900       LDA #LOW INT12903
8A7C A064       LDY #HIGH INT12903
8A7E 20DF67     JSR MOVFM
8A81 20F064     JSR FSUBT
8A84 A963       LDA #LOW FACTMP
8A86 A003       LDY #HIGH FACTMP
8A88 206566     JSR FMULT
8A8B A9F2       LDA #LOW FPM
8A8D A004       LDY #HIGH FPM
8A8F 206566     JSR FMULT
8A92 A263       LDX #LOW FACTMP
8A94 A003       LDY #HIGH FACTMP
```

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```
8A96 200D68      JSR MOVMF

8A99 A993        LDA #LOW FPSPEED10
8A9B A004        LDY #HIGH FPSPEED10
8A9D 20DF67      JSR MOVFM
8AA0 A9DE        LDA #LOW FPV
8AA2 A004        LDY #HIGH FPV
8AA4 206566      JSR FMULT
8AA7 A2CA        LDX #LOW FPARG
8AA9 A003        LDY #HIGH FPARG
8AAB 200D68      JSR MOVMF ;SAVE
8AAE A993        LDA #LOW FPSPEED10
8AB0 A004        LDY #HIGH FPSPEED10
8AB2 20DF67      JSR MOVFM
8AB5 A993        LDA #LOW FPSPEED10
8AB7 A004        LDY #HIGH FPSPEED10
8AB9 206566      JSR FMULT
8ABC A9E3        LDA #LOW FPV2
8ABE A004        LDY #HIGH FPV2
8AC0 206566      JSR FMULT
8AC3 A9CA        LDA #LOW FPARG
8AC5 A003        LDY #HIGH FPARG
8AC7 200465      JSR FADD
8ACA A963        LDA #LOW FACTMP
8ACC A003        LDY #HIGH FACTMP
8ACE 200465      JSR FADD
8AD1 A255        LDX #LOW FPRPWR ;REAL POWER
8AD3 A004        LDY #HIGH FPRPWR
8AD5 200D68      JSR MOVMF

8AD8             DACCALC9 ;KEEP RUNNING STACK OF 10
8AD8 18          CLC
8AD9 A982        LDA #LOW FPRPWRSUM+40
8ADB 8522        STA PNT17
8ADD 6905        ADC #5
8ADF 8520        STA PNT16
8AE1 A904        LDA #HIGH FPRPWRSUM+40
8AE3 8523        STA PNT17+1
8AE5 6900        ADC #0
8AE7 8521        STA PNT16+1
8AE9 A208        LDX #8

8AEB             DACCALC10
8AEB A004        LDY #4

8AED             DACCALC11
8AED B122        LDA (PNT17),Y
8AEF 9120        STA (PNT16),Y
8AF1 88          DEY
8AF2 10F9        BPL DACCALC11
8AF4 CA          DEX
8AF5 3013        BMI DACCALC12
8AF7 38          SEC
8AF8 A522        LDA PNT17
8AFA 8520        STA PNT16
```

```
BAFC E905         SBC #5
BAFE 8522         STA PNT17
BB00 A523         LDA PNT17+1
BB02 8521         STA PNT16+1
BB04 E900         SBC #0
BB06 8523         STA PNT17+1
BB08 80E1         BRA DACCALC10

BB0A              DACCALC12
BB0A A25A         LDX #LOW FPRPWRSUM
BB0C A004         LDY #HIGH FPRPWRSUM
BB0E 200D68       JSR MOVMF

BB11 A9CF         LDA #LOW FPPOWER
BB13 A003         LDY #HIGH FPPOWER
BB15 20C966       JSR CONUPK
BB18 20EAFD       JSR FPDIV
BB1B A263         LDX #LOW FACTMP ;SAVE
BB1D A003         LDY #HIGH FACTMP
BB1F 200D68       JSR MOVMF
BB22 A956         LDA #LOW INT1 ;<1?
BB24 A063         LDY #HIGH INT1
BB26 209468       JSR FCOMP
BB29 3008         BMI DACCALC00 ;YES
BB2B AD0C02       LDA DACTMP ;ALREADY AT FULL LOAD?
BB2E C9FF         CMP #$FF
BB30 D001         BNE *+3 ;NO
BB32 60           RTS ;YES. RETURN WITHOUT CHANGING

BB33              DACCALC00
BB33 A963         LDA #LOW FACTMP
BB35 A003         LDY #HIGH FACTMP
BB37 20DF67       JSR MOVFM
BB3A A9D8         LDA #LOW INT14 ;1.4
BB3C A063         LDY #HIGH INT14
BB3E 209468       JSR FCOMP
BB41 3006         BMI DACCALC0 ;OK, <1.4
                  ;JSR BEEP ;^TEST
BB43 A9D8         LDA #LOW INT14 ;LOAD WITH 1.4
BB45 A063         LDY #HIGH INT14
BB47 8004         BRA DACCALC0A

BB49              DACCALC0
BB49 A963         LDA #LOW FACTMP ;GET VALUE BACK
BB4B A003         LDY #HIGH FACTMP

BB4D              DACCALC0A
BB4D 20DF67       JSR MOVFM

BB50 A944         LDA #LOW FPDAC
BB52 A004         LDY #HIGH FPDAC
BB54 206566       JSR FMULT
BB57 A244         LDX #LOW FPDAC
BB59 A004         LDY #HIGH FPDAC
BB5B 200D68       JSR MOVMF
```

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```
8B5E 20E664     JSR FADDH
8B61 20D468     JSR QINT
8B64 A5D8       LDA FACMOH ;>255?
8B66 F004       BEQ DACCALC2 ;MAYBE NOT

8B68            DACCALC1
8B68 A9FF       LDA #$FF ;LOAD DAC PRETTY HEAVILY
8B6A 8015       BRA DACCALC4

8B6C            DACCALC2 ;TRY NEXT BYTE
8B6C A5D9       LDA FACMO
8B6E D0F8       BNE DACCALC1
8B70 A5DA       LDA FACLO
8B72 D00D       BNE DACCALC4
8B74 A204       LDX #4

8B76            DACCALC3
8B76 BDC963     LDA INT10,X
8B79 9D4404     STA FPDAC,X
8B7C CA         DEX
8B7D 10F7       BPL DACCALC3
8B7F A90A       LDA #10

8B81            DACCALC4
8B81 8D0C02     STA DACTMP
8B84 8DA07F     STA $7FA0
8B87 60         RTS
```

```
                ;COPYRIGHT 1986 FRONTLINE TECHNOLOGY, INC.
92B0*           AUTWRK
92B0*2088D6     JSR RESVAL ;RESET ALL VALUES

92B3*           AUTWRK0
92B3*2068BE     JSR BEEP
92B6*203197     JSR LIMITCALC ;CALCULATE UPPER AND LOWER LIMITS
92B9*20DAEA     JSR MENU30 ;AUTO TARGET MENU
92BC*20B3A3     JSR DSPONG ;DISPLAY ON

92BF*           AUTWRK1
92BF*207CA5     JSR KEYIN ;READ KEYBOARD
92C2*2068BE     JSR BEEP
92C5*C911       CMP #$11 ;START
92C7*D003       BNE *+5
92C9*4C1D95     JMP AUTOSTART
92CC*C912       CMP #$12 ;CHANGE LIMITS
92CE*D003       BNE *+5
92D0*4CE792     JMP AUTWRK2
92D3*C913       CMP #$13 ;CHANGE MAX
92D5*D003       BNE *+5
92D7*4C8D94     JMP AUTWRK3
92DA*C914       CMP #$14
92DC*D0E1       BNE AUTWRK1
92DE*9CD17F     STZ $7FD1
92E1*2096C0     JSR CHRLD
92E4*4C7587     JMP EXMODE ;PREVIOUS MENU

92E7*           AUTWRK2 ;CHANGE LIMITS
92E7*202FF2     JSR MENU31 ;DISPLAY
92EA*2086F3     JSR MENU32

92ED*           AUTWRK2A
92ED*207CA5     JSR KEYIN ;READ KB
92F0*2068BE     JSR BEEP
92F3*C911       CMP #$11 ;UPPER LIMIT
92F5*F00D       BEQ AUTWRK2B
92F7*C912       CMP #$12 ;LOWER LIMIT
92F9*D003       BNE *+5
92FB*4CD493     JMP AUTWRK2J
92FE*C913       CMP #$13 ;PREVIOUS MENU
9300*D0EB       BNE AUTWRK2A
9302*80AF       BRA AUTWRK0

9304*           AUTWRK2B ;UPPER LIMIT
9304*A9FF       LDA #$FF
9306*8D1F02     STA DPFLG ;DP NOT ALLOWED

9309*           AUTWRK2B1
9309*A900       LDA #0 ;CLR BLOCK
930B*8DA224     STA $24A2
930E*8DA324     STA $24A3
9311*8DA424     STA $24A4
9314*8DD824     STA $24D8 ;BLINK OFF
```

Appendix
C

```
9317*8DA924     STA $24A9
931A*A901       LDA #1 ;BLOCK
931C*8DA223     STA $23A2
931F*8DA323     STA $23A3
9322*8DA423     STA $23A4
9325*A902       LDA #2 ;BLINK THESE
9327*8DD923     STA $23D9
932A*A9A0       LDA #$A0
932C*8DD823     STA $23D8

932F*           AUTWRK2C
932F*207CA5     JSR KEYIN
9332*2068BE     JSR BEEP
9335*C911       CMP #$11 ;UPPER LIMIT (AGAIN)
9337*F0D0       BEQ AUTWRK2B
9339*C912       CMP #$12 ;LOWER LIMIT
933B*D003       BNE *+5
933D*4CD493     JMP AUTWRK2J
9340*C913       CMP #$13 ;PREVIOUS MENU
9342*D003       BNE *+5
9344*4CB392     JMP AUTWRK0 ;DOES LIMITCALC
9347*C905       CMP #5 ;-
9349*F04D       BEQ AUTWRK2D
934B*C909       CMP #9 ;+
934D*F062       BEQ AUTWRK2G
934F*C93A       CMP #$3A
9351*B0DC       BCS AUTWRK2C ;>9
9353*C930       CMP #$30
9355*90D8       BCC AUTWRK2C ;<0
9357*48         PHA
9358*A980       LDA #$80
935A*8500       STA ADDR
935C*A923       LDA #$23
935E*8501       STA ADDR+1
9360*A203       LDX #3
9362*867A       STX XSAVE
9364*A022       LDY #34
9366*847E       STY YSAVE
9368*A200       LDX #0
936A*68         PLA
936B*2065A4     JSR INDT01+3
936E*B094       BCS AUTWRK2B ;INVALID KEY
9370*20A0BA     JSR ASCHEX
9373*AE2702     LDX USERID
9376*18         CLC
9377*BD1005     LDA LOWLIM,X
937A*6905       ADC #5
937C*C56C       CMP HEX+1
937E*B084       BCS AUTWRK2B ;BELOW OR = LOW LIMIT+5
9380*18         CLC
9381*A56C       LDA HEX+1
9383*6905       ADC #5
9385*DD3A05     CMP HRTMAX,X
9388*9003       BCC *+5
938A*4C6493     JMP AUTWRK2B ;ABOVE OR = MAX-5
```

```
938D*A5[illegible]     LDA HEX+1
938F*8D2505     STA HIGHLIM,X
9392*203197     JSR LIMITCALC
9395*4CE792     JMP AUTWRK2

9398*           AUTWRK2D ;-
9398*AE2702     LDX USERID
939B*18         CLC
939C*BD1005     LDA LOWLIM,X
939F*6905       ADC #5
93A1*DD2505     CMP HIGHLIM,X
93A4*B0[illegible]       BCS AUTWRK2C ;AT OR BELOW LOW LIMIT+5
93A6*BD2505     LDA HIGHLIM,X
93A9*38         SEC
93AA*E901       SEC #1
93AC*9D2505     STA HIGHLIM,X
93AF*801A       BRA AUTWRK2G1

93B1*           AUTWRK2G ;+
93B1*AE2702     LDX USERID
93B4*18         CLC
93B5*BD2505     LDA HIGHLIM,X
93B8*6905       ADC #5
93BA*DD3A05     CMP HRTMAX,X
93BD*9003       BCC *+5
93BF*4C2F93     JMP AUTWRK2C ;ALREADY AT MAX
93C2*18         CLC
93C3*BD2505     LDA HIGHLIM,X
93C6*6901       ADC #1
93C8*9D2505     STA HIGHLIM,X

93CB*           AUTWRK2G1
93CB*203197     JSR LIMITCALC
93CE*2039F3     JSR MENU31A
93D1*4C0993     JMP AUTWRK2B1

93D4*           AUTWRK2J ;LOWER LIMIT
93D4*A900       LDA #0
93D6*8DA223     STA $23A2 ;CLR BLOCK
93D9*8DA323     STA $23A3
93DC*8DA423     STA $23A4
93DF*8DD823     STA $23D8 ;CLR BLINK
93E2*8DD923     STA $23D9
93E5*A901       LDA #1
93E7*8DA224     STA $24A2 ;BLOCK
93EA*8DA324     STA $24A3
93ED*8DA424     STA $24A4
93F0*A9A0       LDA #$A0
93F2*8DD824     STA $24D8
93F5*A902       LDA #2
93F7*8DD924     STA $24D9
93FA*A9FF       LDA #$FF
93FC*8D1F02     STA DPFLG ;NO DP

93FF*           AUTWRK2K
```

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Huntsville Macro Assembler 65C02 cross assembler for PC-DOS 2.0 v1.92_ Page
Module: BIMIA

```
93FF*207CA5     JSR KEYIN
9402*2068EE     JSR BEEP
9405*C911       CMP #$11 ;UPPER LIMIT
9407*D003       BNE *+5
9409*4C0493     JMP AUTWRK2B
940C*C912       CMP #$12 ;LOWER LIMIT (AGAIN)
940E*F0EF       BEQ AUTWRK2K
9410*C913       CMP #$13 ;PREVIOUS MENU
9412*D003       BNE *+5
9414*4CB392     JMP AUTWRK0

9417*C905       CMP #5 ;-
9419*F042       BEQ AUTWRK2M
941B*C909       CMP #9 ;+
941D*F04E       BEQ AUTWRK2N
941F*C93A       CMP #$3A
9421*B0DC       BCS AUTWRK2K ;>9
9423*C930       CMP #$30
9425*90D8       BCC AUTWRK2K ;<0
9427*48         PHA
9428*A980       LDA #$80
942A*8500       STA ADDR
942C*A924       LDA #$24
942E*8501       STA ADDR+1
9430*A203       LDX #3
9432*867A       STX XSAVE
9434*A022       LDY #34
9436*847E       STY YSAVE
9438*A200       LDX #0
943A*68         PLA
943B*2065A4     JSR INDT01+3
943E*B094       BCS AUTWRK2J ;INVALID KEY
9440*20A0BA     JSR ASCHEX
9443*AE2702     LDX USERID
9446*A56C       LDA HEX+1
9448*F08A       BEQ AUTWRK2J ;0
944A*18         CLC
944B*6905       ADC #5
944D*DD2505     CMP HIGHLIM,X
9450*B082       BCS AUTWRK2J ;AT OR ABOVE HIGH LIMIT-5
9452*A56C       LDA HEX+1
9454*9D1005     STA LOWLIM,X
9457*203197     JSR LIMITCALC
945A*4CE792     JMP AUTWRK2


945D*           AUTWRK2M ;-
945D*AE2702     LDX USERID
9460*BD1005     LDA LOWLIM,X
9463*F09A       BEQ AUTWRK2K ;ALREADY 0
9465*38         SEC
9466*E901       SBC #1
9468*9D1005     STA LOWLIM,X
946B*8017       BRA AUTWRK2N1
```

```
946D*                AUTWRK2N ;+
946D*AE2702          LDX USERID
9470*18              CLC
9471*BD1005          LDA LOWLIM,X
9474*6905            ADC #5
9476*DD2505          CMP HIGHLIM,X
9479*B034            BCS AUTWRK2K ;ALREADY AT HIGH LIMIT-5
947B*18              CLC
947C*BD1005          LDA LOWLIM,X
947F*6901            ADC #1
9481*9D1005          STA LOWLIM,X

9484*                AUTWRK2N1
9484*203197          JSR LIMITCALC
9487*2039F3          JSR MENU31A
948A*4CD493          JMP AUTWRK2J

948D*                AUTWRK3
948D*209EF3          JSR MENU33

9490*                AUTWRK3A
9490*A901            LDA #1
9492*8D9823          STA $2398 ;BLOCK
9495*8D9923          STA $2399
9498*8D9A23          STA $239A
949B*A92A            LDA #$2A
949D*8DD623          STA $23D6
94A0*A9FF            LDA #$FF
94A2*8D1F02          STA DPFLG ;NO DF

94A5*                AUTWRK3B
94A5*207CA5          JSR KEYIN
94A8*2068BE          JSR BEEP
94AB*C911            CMP #$11 ;PREVIOUS MENU
94AD*D003            BNE *+5
94AF*4CB392          JMP AUTWRK0

94B2*C905            CMP #5 ;-
94B4*F03A            BEQ AUTWRK3C
94B6*C909            CMP #9 ;+
94B8*F047            BEQ AUTWRK3D
94BA*C93A            CMP #$3A
94BC*B0E7            BCS AUTWRK3B ;>9
94BE*C930            CMP #$30
94C0*90E3            BCC AUTWRK3B ;<0
94C2*48              PHA
94C3*A980            LDA #$80
94C5*8500            STA ADDR
94C7*A923            LDA #$23
94C9*8501            STA ADDR+1
94CB*A203            LDX #3
94CD*867A            STX XSAVE
94CF*A018            LDY #24
94D1*847E            STY YSAVE
94D3*A200            LDX #0
```

```
94D5*68             PLA
94D6*20E544         JSR INDT01+3
94D9*B0EE           BCS AUTWRK3A ;INVALID KEY
94DB*20A0BA         JSR ASCHEX
94DE*AE2702         LDX USERID
94E1*A56C           LDA HEX+1
94E3*C9DD           CMP #221
94E5*B0A9           BCS AUTWRK3A ;>220
94E7*9D3A05         STA HRTMAX,X
94EA*208D86         JSR UPLOWCALC ;CALCULATE NEW LIMITS
94ED*4CB392         JMP AUTWRK0


94F0*               AUTWRK3C ;-
94F0*AE2702         LDX USERID
94F3*BD3A05         LDA HRTMAX,X
94F6*38             SEC
94F7*E901           SBC #1
94F9*9D3A05         STA HRTMAX,X
94FC*208D86         JSR UPLOWCALC ;CALCULATE NEW LIMITS
94FF*8013           BRA AUTWRK3D1

9501*               AUTWRK3D ;+
9501*AE2702         LDX USERID
9504*BD3A05         LDA HRTMAX,X
9507*C9DC           CMP #220
9509*B09A           BCS AUTWRK3B ;ALREADY AT 220
950B*18             CLC
950C*6901           ADC #1
950E*9D3A05         STA HRTMAX,X
9511*208D86         JSR UPLOWCALC ;CALCULATE NEW LIMITS

9514*               AUTWRK3D1
9514*203197         JSR LIMITCALC
9517*20EDF3         JSR MENU33A
951A*4C9094         JMP AUTWRK3A


951D*               AUTOSTART ;START AUTO TARGET
951D*20BAED         JSR MENU30ASOFT ;SOFT KEYS
9520*20728D         JSR LDINITDAC ;INITIALIZE A/D, LOAD VALUES IN FLOATING POINT
9523*209FA8         JSR IRQENABLE
9526*9C6F05         STZ INCFLG
9529*9C6E05         STZ DECFLG
952C*9C7005         STZ FACEFLG
952F*A909           LDA #9 ;10 READINGS
9531*8D4903         STA HRTCNT
9534*2057F0         JSR WARMUP ;"WARM-UP"

9537*               AUTOS1
9537*645F           STZ KEY

9539*               AUTOS2
9539*2062B7         JSR RPMCALC ;CALCULATE SPEED
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953C*20D1B7      JSR CADCALC ;CALCULATE CADENCE
953F*204CE9      JSR HEARTCALC ;CALCULATE HEART RATE
9542*202B8D      JSR ADAVG ;RUNNING TOTAL OF 10 A/D READINGS
9545*A5A3        LDA TIMER2 ;1 SEC?
9547*D003        BNE *+5 ;NO
9549*4CA695      JMP AUTOS5
954C*A5A7        LDA TIMER6 ;0.24 SEC?
954E*D00A        BNE AUTOS2A ;NO
9550*A906        LDA #6 ;RESET
9552*85A7        STA TIMER6
9554*20076A      JSR SPEEDDIV10 ;CALCULATE TRUE SPEED (DIVIDE BY 10)
9557*20198A      JSR DACCALC ;CALCULATE NEW DAC VALUE

955A*            AUTOS2A
955A*A55F        LDA KEY ;KB?
955C*F01A        BEQ AUTOS2B ;NO
955E*C911        CMP #$11 ;STOP
9560*F010        BEQ AUTOS2A1
9562*C912        CMP #$12 ;TURN ON/OFF HEART RATE BEEP
9564*D0D1        BNE AUTOS1
9566*20688E      JSR BEEP
9569*A202        LDX #2 ;ROW 2
956B*208892      JSR HRBEEPTOGGLEL ;TOGGLE HEART RATE BEEP
956E*645F        STZ KEY
9570*8006        BRA AUTOS2B

9572*            AUTOS2A1
9572*20B4C3      JSR STOPVAL ;PUT SOME VALUES TO 0
9575*4CB392      JMP AUTWRK0 ;^??

9578*            AUTOS2B
9578*AD0A02      LDA STARTFLG
957B*D0BC        BNE AUTOS2 ;PAST WARMUP
957D*AD1E03      LDA ELTIMMIN
9580*C902        CMP #2
9582*90B5        BCC AUTOS2 ;NOT 2 MIN YET
9584*206CF0      JSR CLRFACE ;ERASE "WARM UP"
9587*CE0A02      DEC STARTFLG ;=$FF
958A*A955        LDA #LOW FPRPWR ;GET PRESENT POWER
958C*A004        LDY #HIGH FPRPWR
958E*20DF67      JSR MOVFM
9591*203B67      JSR DIV10 ;DIVIDE BY 10
9594*20E664      JSR FADDH ;ROUND
9597*200569      JSR INT ;TO INTEGER
959A*201F67      JSR MUL10 ;MULTIPLY BY 10
959D*A2CF        LDX #LOW FPPOWER ;STORE IN POWER
959F*A003        LDY #HIGH FPPOWER
95A1*200D68      JSR MOVMF
95A4*8093        BRA AUTOS2

95A6*            AUTOS5 ;1 SEC
95A6*A919        LDA #25 ;RESET
95A8*85A3        STA TIMER2
95AA*208BF0      JSR UPMEN30 ;UPDATE ALL NUMBERS
95AD*AD0A02      LDA STARTFLG ;RUNNING?
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```
95B0*D003        BNE AUTOS6 ;YES
95B2*4C3995      JMP AUTOS2

95B5*            AUTOS6
95B5*A9AC        LDA #LOW FPHRTAVG ;GET AVG HEART RATE
95B7*A004        LDY #HIGH FPHRTAVG
95B9*20DF67      JSR MOVFM
95BB*A9B1        LDA #LOW FPLOWTEST ;COMPARE WITH LOW LIMIT
95BD*A004        LDY #HIGH FPLOWTEST
95C0*209468      JSR FCOMP ;UNDER LOW LIMIT?
95C3*3003        BMI AUTOS7 ;YES
95C5*4C6F96      JMP AUTOS9 ;CHECK IF ABOVE HIGH

95C8*            AUTOS7
95C8*AD7005      LDA FACEFLG ;FACE ON?
95CB*D005        BNE AUTOS7A ;YES
95CD*AD6E05      LDA DECFLG ;DECREASE ARROW?
95D0*F009        BEQ AUTOS7B ;NO

95D2*            AUTOS7A
95D2*206CF0      JSR CLRFACE ;CLEAR FACE
95D5*9C7005      STZ FACEFLG
95D8*9C6E05      STZ DECFLG

95DB*            AUTOS7B
95DB*AD6F05      LDA INCFLG ;INCREASED LAST TIME?
95DE*F00A        BEQ AUTOS8 ;NO
95E0*AD2C03      LDA SPTIMSEC
95E3*C928        CMP #40 ;40 SEC YET?
95E5*B003        BCS *+5 ;YES
95E7*4C3995      JMP AUTOS2

95EA*            AUTOS8
95EA*9C2C03      STZ SPTIMSEC ;RESET TIMER
95ED*9C2D03      STZ SPTIMTNTH

95F0*A9FF        LDA #$FF
95F2*8D6F05      STA INCFLG
95F5*9C6E05      STZ DECFLG
95F8*9C7005      STZ FACEFLG
95FB*AD2903      LDA SPDHEX
95FE*D00A        BNE AUTOS8AA
9600*AD2A03      LDA SPDHEX+1
9603*C950        CMP #80 ;< 8 MPH?
9605*B003        BCS AUTOS8AA ;NO
9607*4CDD96      JMP AUTOS11AA ;DECREASE LOAD

960A*            AUTOS8AA
960A*A9FF        LDA #$FF
960C*CD0C02      CMP DACTMP ;DAC FULL?
960F*F010        BEQ AUTOS8A ;YES
9611*A9CF        LDA #LOW FPPOWER ;POWER < 1000?
9613*A003        LDY #HIGH FPPOWER
9615*20DF67      JSR MOVFM
9618*A91E        LDA #LOW INT1000
```

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961A*A064        LDY #HIGH INT1000
961C*209468      JSR FCOMP
961F*3006        BMI AUTOS8B ;YES

9621*            AUTOS8A
9621*201FEF      JSR INCREASEEFFORT

9624*4C3995      JMP AUTOS2

9627*            AUTOS8B
9627*A9AC        LDA #LOW FPHRTAVG
9629*A004        LDY #HIGH FPHRTAVG
962B*20DF67      JSR MOVFM
962E*A9B1        LDA #LOW FPLOWTEST
9630*A004        LDY #HIGH FPLOWTEST
9632*20ED64      JSR FSUB ;GET DIFFERENCE IN HEART RATE
9635*203B67      JSR DIV10 ;DIVIDE BY 10
9638*20E664      JSR FADDH ;ROUND
963B*200569      JSR INT ;TO INTEGER
963E*A263        LDX #LOW FACTMP ;SAVE
9640*A003        LDY #HIGH FACTMP
9642*200D68      JSR MOVMF
9645*A956        LDA #LOW INT1 ;<1?
9647*A063        LDY #HIGH INT1
9649*209468      JSR FCOMP
964C*1006        BPL AUTOS8C ;NO
964E*A956        LDA #LOW INT1 ;USE 1
9650*A063        LDY #HIGH INT1
9652*8004        BRA AUTOS8D

9654*            AUTOS8C
9654*A963        LDA #LOW FACTMP ;GET BACK
9656*A003        LDY #HIGH FACTMP

9658*            AUTOS8D
9658*20DF67      JSR MOVFM
965B*201F67      JSR MUL10 ;MULTIPLY BY 10

965E*A9CF        LDA #LOW FPPOWER ;INCREASE THAT AMOUNT
9660*A003        LDY #HIGH FPPOWER
9662*200465      JSR FADD
9665*A2CF        LDX #LOW FPPOWER ;SAVE
9667*A003        LDY #HIGH FPPOWER
9669*200D68      JSR MOVMF
966C*4C3995      JMP AUTOS2

966F*            AUTOS9 ;CHECK FOR ABOVE LIMIT
966F*A9AC        LDA #LOW FPHRTAVG
9671*A004        LDY #HIGH FPHRTAVG
9673*20DF67      JSR MOVFM
9676*A9BB        LDA #LOW FPHIGHTST5 ;> UPPER LIMIT + 5?
9678*A004        LDY #HIGH FPHIGHTST5
967A*209468      JSR FCOMP
967D*C901        CMP #1
967F*D003        BNE *+5
```

```
9681*4C2097     JMP AUTOS13 ;YES

9684*A9AC       LDA #LOW FPHRTAVG
9686*A004       LDY #HIGH FPHRTAVG
9688*20DF67     JSR MOVFM
968B*A9B6       LDA #LOW FPHIGHTEST
968D*A004       LDY #HIGH FPHIGHTEST
968F*2094C5     JSR FCOMP ;OVER LIMIT?
9692*C901       CMP #1
9694*F01C       BEQ AUTOS10 ;YES
9696*AD7005     LDA FACEFLG ;HAPPY FACE ALREADY ON?
9699*D00E       BNE AUTOS9A ;YES
969B*20C9ED     JSR HAPPYFACE
969E*A9FF       LDA #$FF
96A0*8D7005     STA FACEFLG
96A3*8D6F05     STA INCFLG
96A6*8D6E05     STA DECFLG

96A9*           AUTOS9A
96A9*9C2C03     STZ SPTIMSEC ;RESET TIMER
96AC*9C2D03     STZ SPTIMTNTH
96AF*4C3995     JMP AUTOS2

96B2*           AUTOS10
96B2*AD7005     LDA FACEFLG ;FACE ON?
96B5*D005       BNE AUTOS10A ;YES
96B7*AD6E05     LDA DECFLG ;DECREASE ARROW?
96BA*F009       BEQ AUTOS10B ;NO

96BC*           AUTOS10A
96BC*206CF0     JSR CLRFACE
96BF*9C6F05     STZ INCFLG
96C2*9C7005     STZ FACEFLG

96C5*           AUTOS10B
96C5*AD6E05     LDA DECFLG ;JUST DECREASED?
96C8*F00A       BEQ AUTOS11 ;NO
96CA*AD2C03     LDA SPTIMSEC ;20 SEC UP?
96CD*C914       CMP #20
96CF*B003       BCS *+5
96D1*4C3995     JMP AUTOS2 ;NO

96D4*           AUTOS11
96D4*9C6F05     STZ INCFLG
96D7*9C7005     STZ FACEFLG
96DA*CE6E05     DEC DECFLG ;= $FF

96DD*           AUTOS11AA
96DD*9C2D03     STZ SPTIMTNTH ;RESET TIMERS
96E0*9C2C03     STZ SPTIMSEC
96E3*AD0C02     LDA DACTMP ;DAC AT 0?
96E6*F010       BEQ AUTOS11A ;YES
96E8*A923       LDA #LOW INT0 ;POWER > 0?
96EA*A064       LDY #HIGH INT0
96EC*20DF67     JSR MOVFM
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```
96EF*A9CF        LDA #LOW FPPOWER
96F1*A003        LDY #HIGH FPPOWER
96F3*209468      JSR FCOMP
96F6*3010        BMI AUTOS12 ;NO

96F8*            AUTOS11A
96F8*2C6E05      BIT DECFLG ;DECREASE ALREADY ON?
96FB*3008        BMI AUTOS11C ;YES

96FD*            AUTOS11B
96FD*20B9EF      JSR DECREASEEFFORT
9700*A9FF        LDA #$FF
9702*8D6E05      STA DECFLG

9705*            AUTOS11C
9705*4C3995      JMP AUTOS2

9708*            AUTOS12
                 ;JSR CLRFACE
9708*A9C9        LDA #LOW INT10
970A*A063        LDY #HIGH INT10
970C*20DF67      JSR MOVFM
970F*A9CF        LDA #LOW FPPOWER
9711*A003        LDY #HIGH FPPOWER
9713*20ED64      JSR FSUB ;DECREASE BY 10
9716*A2CF        LDX #LOW FPPOWER
9718*A003        LDY #HIGH FPPOWER
971A*200D68      JSR MOVMF
971D*4C3995      JMP AUTOS2

9720*            AUTOS13
9720*9CA07F      STZ $7FA0 ;0 DAC
9723*9C0C02      STZ DACTMP
9726*9CCF03      STZ FPPOWER
9729*9C7005      STZ FACEFLG
972C*9C6F05      STZ INCFLG
972F*80CC        BRA AUTOS11B


9731*            LIMITCALC ;CALCULATE LIMITS
9731*2033F4      JSR RDYFAC
9734*AE2702      LDX USERID
9737*BD1005      LDA LOWLIM,X
973A*85DA        STA FACLO
973C*207565      JSR NORMAL
973F*A2C0        LDX #LOW FPLOWLIM
9741*A004        LDY #HIGH FPLOWLIM
9743*200D68      JSR MOVMF

9746*2033F4      JSR RDYFAC
9749*AE2702      LDX USERID
974C*BD2505      LDA HIGHLIM,X
974F*85DA        STA FACLO
9751*207565      JSR NORMAL
9754*A2C5        LDX #LOW FPHIGHLIM
```

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Module: [illegible]

```
9756*A004       LDY #HIGH FPHIGHLIM
9758*200D68     JSR MOVMF

975B*2033F4     JSR RDYFAC
975E*AE2702     LDX USERID
9761*BD3A05     LDA HPTMAX,X
9764*85D4       STA FACLO
9766*207565     JSR NORMAL
9769*204568     JSR MOVAF
976C*A919       LDA #LOW INT100
976E*A064       LDY #HIGH INT100
9770*20DF67     JSR MOVFM
9773*20E4FD     JSR FPDIV
9776*A2C4       LDX #LOW FPMAX
9778*A004       LDY #HIGH FPMAX
977A*200D68     JSR MOVMF

977D*A9C0       LDA #LOW FPLOWLIM
977F*A004       LDY #HIGH FPLOWLIM
9781*20DF67     JSR MOVFM
9784*A9C5       LDA #LOW FPHIGHLIM
9786*A004       LDY #HIGH FPHIGHLIM
9788*20ED64     JSR FSUB ;HIGH - LOW
978B*A941       LDA #LOW INTPT2
978D*A064       LDY #HIGH INTPT2
978F*206566     JSR FMULT ;* 0.2
9792*A263       LDX #LOW FACTMP ;SAVE
9794*A003       LDY #HIGH FACTMP
9796*200D68     JSR MOVMF

9799*A9C0       LDA #LOW FPLOWLIM
979B*A004       LDY #HIGH FPLOWLIM
979D*200465     JSR FADD ;+ LOW
97A0*A2B1       LDX #LOW FPLOWTEST
97A2*A004       LDY #HIGH FPLOWTEST
97A4*200D68     JSR MOVMF

97A7*A963       LDA #LOW FACTMP
97A9*A003       LDY #HIGH FACTMP
97AB*20DF67     JSR MOVFM
97AE*A9C5       LDA #LOW FPHIGHLIM
97B0*A004       LDY #HIGH FPHIGHLIM
97B2*20ED64     JSR FSUB ;HIGH - 0.2*DIFF
97B5*A2B6       LDX #LOW FPHIGHTEST
97B7*A004       LDY #HIGH FPHIGHTEST
97B9*200D68     JSR MOVMF

97BC*A9C5       LDA #LOW FPHIGHLIM
97BE*A004       LDY #HIGH FPHIGHLIM
97C0*20DF67     JSR MOVFM
97C3*A99C       LDA #LOW INT5
97C5*A063       LDY #HIGH INT5
97C7*200465     JSR FADD
97CA*A2BB       LDX #LOW FPHIGHTST5
97CC*A004       LDY #HIGH FPHIGHTST5
```

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97CE*200D68     JSR MOVMF ;UPPER LIMIT + 5

97D1*A9E1       LDA #LOW FPLOWTEST
97D3*A004       LDY #HIGH FPLOWTEST
97D5*20F597     JSR LIMITADDRCALC ;CALCULATE LOW LIMIT ADDRESS
97D8*A500       LDA ADDR ;SAVE ADDRESS
97DA*851A       STA PNT13
97DC*A501       LDA ADDR+1
97DE*851B       STA PNT13+1
97E0*202798     JSR LIMITDSP ;DRAW LINE
97E3*A9E6       LDA #LOW FPHIGHTEST
97E5*A004       LDY #HIGH FPHIGHTEST
97E7*20F597     JSR LIMITADDRCALC
97EA*A500       LDA ADDR ;SAVE ADDRESS OF HIGH LIMIT
97EC*851C       STA PNT14
97EE*A501       LDA ADDR+1
97F0*851D       STA PNT14+1
97F2*4C2798     JMP LIMITDSP ;NOW DRAW LINE AND RTN

97F5*           LIMITADDRCALC
97F5*20C966     JSR CONUPK
97F8*A94B       LDA #LOW INT31
97FA*A064       LDY #HIGH INT31
97FC*20DF67     JSR MOVFM
97FF*20F064     JSR FSUBT
9802*A946       LDA #LOW INTPT55
9804*A064       LDY #HIGH INTPT55
9806*206566     JSR FMULT
9809*20E664     JSR FADDH
980C*200569     JSR INT
980F*A950       LDA #LOW INT64
9811*A064       LDY #HIGH INT64
9813*206566     JSR FMULT
9816*20D468     JSR QINT
9819*38         SEC
981A*A980       LDA #$80
981C*E5DA       SBC FACLO
981E*8500       STA ADDR
9820*A93F       LDA #$3F
9822*E5D9       SBC FACMO
9824*8501       STA ADDR+1
9826*60         RTS

9827*           LIMITDSP ;DRAW DOUBLE LINE AT ADDRESS
9827*A003       LDY #3
9829*A90F       LDA #$0F
982B*9100       STA (ADDR),Y
982D*C8         INY
982E*A9FF       LDA #$FF

9830*           LIMITDSP1
9830*9100       STA (ADDR),Y
9832*C8         INY
9833*C008       CPY #8
9835*D0F9       BNE LIMITDSP1
```

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9837*207FA7      JSR ADD40
983A*A003        LDY #3
983C*A90F        LDA #$0F
983E*9100        STA (ADDR),Y
9840*C8          INY
9841*A9FF        LDA #$FF

9843*            LIMITDSP2
9843*9100        STA (ADDR),Y
9845*C8          INY
9846*C008        CPY #8
9848*D0F9        BNE LIMITDSP2

984A*60          RTS
```

WE CLAIM:

1. A method of calibrating an exercise device containing a rotating wheel and a loading device for applying loads to that wheel, comprising the steps of:

rotating a wheel in an exercising device until the wheel attains at least a first predetermined rotational velocity;

allowing the wheel to coast down to a second predetermined rotational velocity during which coasting period the loading device is not exerting loads on the wheel other than inherent frictional loads;

sensing and recording the time and rotational velocity at periodic intervals as the wheel coasts down from the first velocity to the second velocity;

determining the rotational mass moment of inertia of any components of the exercise device that rotate because the wheel rotates;

performing a linear regression analysis on the recorded velocities and times to determine the deceleration of the wheel and rotating components as a function of velocity; and

deriving the frictional load from rotation of the wheel and the rotating components of the exercise device from the formula Frictional torque equals the Mass Inertia times the Angular deceleration.

2. A method as defined in Claim 1, wherein the velocity and time data are taken with the wheel rotating between the speeds of at least 23 miles per hour, and 5 miles per hour, and wherein there are sufficient velocity and time readings that every 20 velocity readings are averaged together to form a series of velocities upon which the linear regression can be performed.

3. A method as defined in Claim 1, comprising the further step of:

computing the power required to overcome the frictional load from the formula: Power equals Torque

times angular velocity.

4. A method as defined in Claim 1, comprising the further step of:

determining the efficiency of the loading device;

determining the power output of the loading device by comparing the efficiency of the loading device with a second loading device for which the power output is known; and

adjusting the loading device to account for the frictional losses and the efficiency of the loading device.

5. A method as defined in Claim 4, wherein the efficiency is determined by performing a linear regression analysis to determine the power dissipated by the loading device at a predetermined speed, and by performing a linear regression analysis to determine the power which the loading device applies to the wheel.

6. A method as defined in Claim 4, wherein said loading device comprises an electrical device which exerts a load on the wheel where the load can be varied by varying the voltage applied to the loading device, and wherein the power dissipated is determined by the steps comprising:

rotating the wheel until the wheel attains at least a third predetermined rotational velocity;

allowing the wheel to decelerate to a fourth predetermined rotational velocity;

applying a constant decelerating force from the electrical device in order to further decelerate the wheel as it decelerates from the third to the fourth velocities;

sensing and recording both the rotational velocity of the wheel and the voltage output by the electrical device at periodic intervals of time as the wheel decelerates from the third velocity to the forth velocity;

performing a linear regression analysis on the recorded wheel velocity and the square of the voltage

output from the coast down between the third and fourth velocities to determine the deceleration of the wheel and rotating components as a function of velocity; and

wherein the power output by the loading device is further determined by the step comprising:

performing a linear regression analysis on the velocity and on the deceleration times the velocity from the coast down between the third and fourth velocities in order to obtain linear regression constants for use in determining the power applied.

7. A method of accurately and realistically simulating environmental loads in a stationary exercise apparatus, comprising the steps of:

mounting a bicycle in a support apparatus so a rear tire of the bicycle rides against at least one roller;

connecting a loading device to the exercise apparatus so the loading apparatus can exert a controllable load on the rear tire; pedaling the bicycle until the rear tire reaches a first predetermined rotational velocity;

letting the rear tire coast down to a second predetermined velocity while the loading device exerts no loads other than its inherent frictional loads;

sensing and recording the velocity of the rear tire at periodic time intervals as the tire coasts from the first velocity to the second velocity;

determining the rotational mass moment of inertia of any components of the bicycle and support apparatus that rotate with the wheel during the coast down period;

performing a linear regression analysis on the recorded velocities and times to determine the deceleration of the rear tire and rotating components as a function of velocity; and

deriving the frictional load from rotation of the tire and the rotating components from the formula: Frictional torque equals the Mass Inertia times the Angular

deceleration.

8. A method as defined in Claim 7, further comprising the steps of:

determining the efficiency of the loading device;

determining the power output of the loading device by comparing the efficiency of the loading device with a second loading device for which the power output is known; and

adjusting the loading device to account for the frictional losses and the efficiency of the loading device.

9. A method as defined in Claim 8, wherein the linear regression step comprises:

performing a linear regression analysis on the recorded times and velocities between a third velocity and the second velocity to determine the deceleration of the rear tire and rotating components as a function of velocity, where the third velocity is between the first and second velocities.

10. A method as defined in Claim 9, further comprising the step of:

connecting a flywheel to the support apparatus so the rear tire causes the flywheel to rotate and simulate the inertia of a rider and bicycle, and where the mass moment of inertia includes the inertia of the flywheel.

11. A method as defined in Claim 10, wherein the loading device comprises an alternator which can exert a controllable load on the rear tire by controllably varying the voltage applied to the alternator, and wherein the efficiency of the alternator is determined by determining the power dissipated by the alternator and the power output by the alternator, the power being dissipated being determined by comprising the steps of:

rotating the wheel until the wheel attains a fourth predetermined rotational velocity;

allowing the wheel to decelerate to a fifth predetermined rotational velocity;

applying a constant decelerating force from the alternator in order to further decelerate the wheel as it decelerates from the fourth to the fifth velocity;

sensing and recording the rotational velocity of the wheel and the voltage output by the electrical device at periodic intervals as the wheel decelerates from the fourth velocity to the fifth velocity;

performing a linear regression analysis on the recorded wheel velocity and the square of the voltage to determine the deceleration of the wheel and rotating components as a function of velocity; and wherein

the power output by the alternator is determined by the steps comprising:

performing a linear regression analysis on the velocity and on the deceleration times the velocity in order to obtain linear regression constants for use in determining the power applied.

12. An exercise device which realistically simulates the pedal resistance, body position and feel of riding a bicycle, including performance periods when the user is not sitting on the saddle but is instead leaning over the front handlebars and essentially standing on the pedals, comprising:

a stationary frame for mounting components of a bicycle, said bicycle including a rear wheel, a rear tire and a rear axle, a frame, a seat, a front fork, handlebars and pedals, wherein said stationary frame comprises:

rear axle support means for connecting to opposite ends of said rear axle without preventing rotation of said rear wheel and tire, said rear axle support means constraining said rear axle, wheel and tire to move along a predetermined path;

fork support means for connecting to and

supporting said front fork, said fork support means being movable in response to a shift in the weight of a rider;

a roller mounted to said frame so as to frictionally engage said rear tire of the bicycle when said rear axle is connected to said rear axle support means, said roller and said rear axle support means cooperating to support said rear wheel and tire when said rear axle is connected to said rear axle support means so as to maintain frictional contact between said roller and said rear tire whose axle is connected to said rear support means, as the weight of a rider is shifted toward said fork support means, so as to prevent slippage between said roller and said rear tire;

flywheel means communicating with said roller to simulate the momentum a rider and bicycle achieve during actual riding of a bicycle;

variable load-applying means communicating with said roller for applying variable loads to said roller to simulate variations in the load encountered during actual riding of a bicycle; and

calibration means for determining the friction retarding the wheel from rotating so the variable load-applying means can compensate for said friction.

13. An exercise device as defined in Claim 12, wherein said rear axle support means comprises at least one rotatable member constrained to rotate about an axis substantially parallel to the rotational axis of a rear wheel of the bicycle when said wheel is connected to said rear axle support means.

14. An exercise device as defined in Claim 12, wherein said rotational axis of said rear axis support means and the rotational axis of said roller are located on opposite sides of a substantially vertical plane through a rear axle of a bicycle connected to said rear axle support

means.

15. An exercise device as defined in Claim 12, wherein said predetermined path is arcuate.

16. An apparatus for use in exercising with a bicycle, comprising:

rotatable support means for supporting a rear wheel and tire of a bicycle by frictionally engaging said tire;

movable support means cooperating with said rotatable support means to support said rear wheel and tire, said movable support means constraining said rear wheel and tire to move along a predetermined path to bring said tire into frictional engagement with said rotatable support means;

inertia means communicating with said rotatable support means to simulate momentum during actual riding of a bicycle;

variable load-applying means communicating with said rotatable support means for applying variable loads to said rotatable support means in order to simulate variations in loads encountered during actual riding of a bicycle; and

calibrating means to calibrate the friction in rotating said rear wheel so said variable load-applying means can compensate for said friction.

17. An apparatus as defined in Claim 16 wherein said calibrating means further comprises means for determining the efficiency of said variable load-applying means so said load-applying means can compensate for the inefficiencies of said load-applying means.

18. An apparatus as defined in Claim 17, wherein said movable support means comprises pivoting support means which pivot about an axis substantially parallel to the rotational axis of the rear wheel and tire supported by said support means.

19. An apparatus as defined in Claim 17, further comprising fork support means for connecting to and supporting a front fork of a bicycle when the rear wheel of

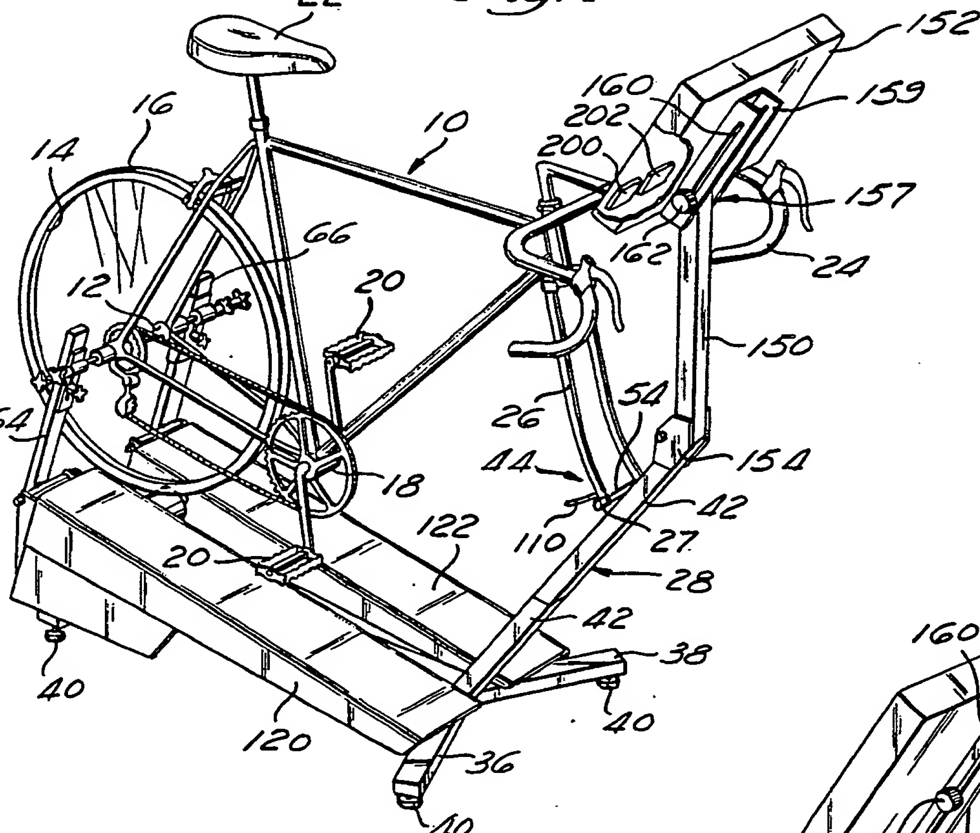
said bicycle is supported by said rotatable support means and said pivoting support means, said fork support means being connected to said pivoting support means such that movement of said fork support means cooperates with said pivoting support means to maintain frictional contact between said rotatable support means and said rear tire of said bicycle when said bicycle is supported by said rotatable support means and said pivoting support means.

20. An apparatus as defined in Claim 19, further comprising joint means on said front fork support means and said rear axle support means for positioning said front axle support and said rear axle support member in adjacent relationship to said frame to form a smaller, portable configuration of said apparatus.

21. An exercise device as defined in Claim 12, further comprising decreased heart rate means operating when said person's heart rate is below a first predetermined lower limit in order to increase said heart rate, said decreased heart rate means determining whether the loads exerted by the variable load means just increased and if so whether said load has been unchanged for a predetermined period of time, said decreased heart rate means causing said variable load means to increase the load if the load is below a predetermined maximum value.

22. An exercise device as defined in Claim 21 further comprising increased heart rate means operating when said person's heart rate is above a third predetermined limit in order to decrease said heart rate, said increased heart rate means determining whether the load exerted by said variable load means just increased, and if said load has been at an increased level for a predetermined time said increased heart rate means causes said variable load means to increase the load, said increased heart rate means decreasing said load exerted by said variable load means if said load has not just decreased and if said load is not below a predetermined value.

Fig. 1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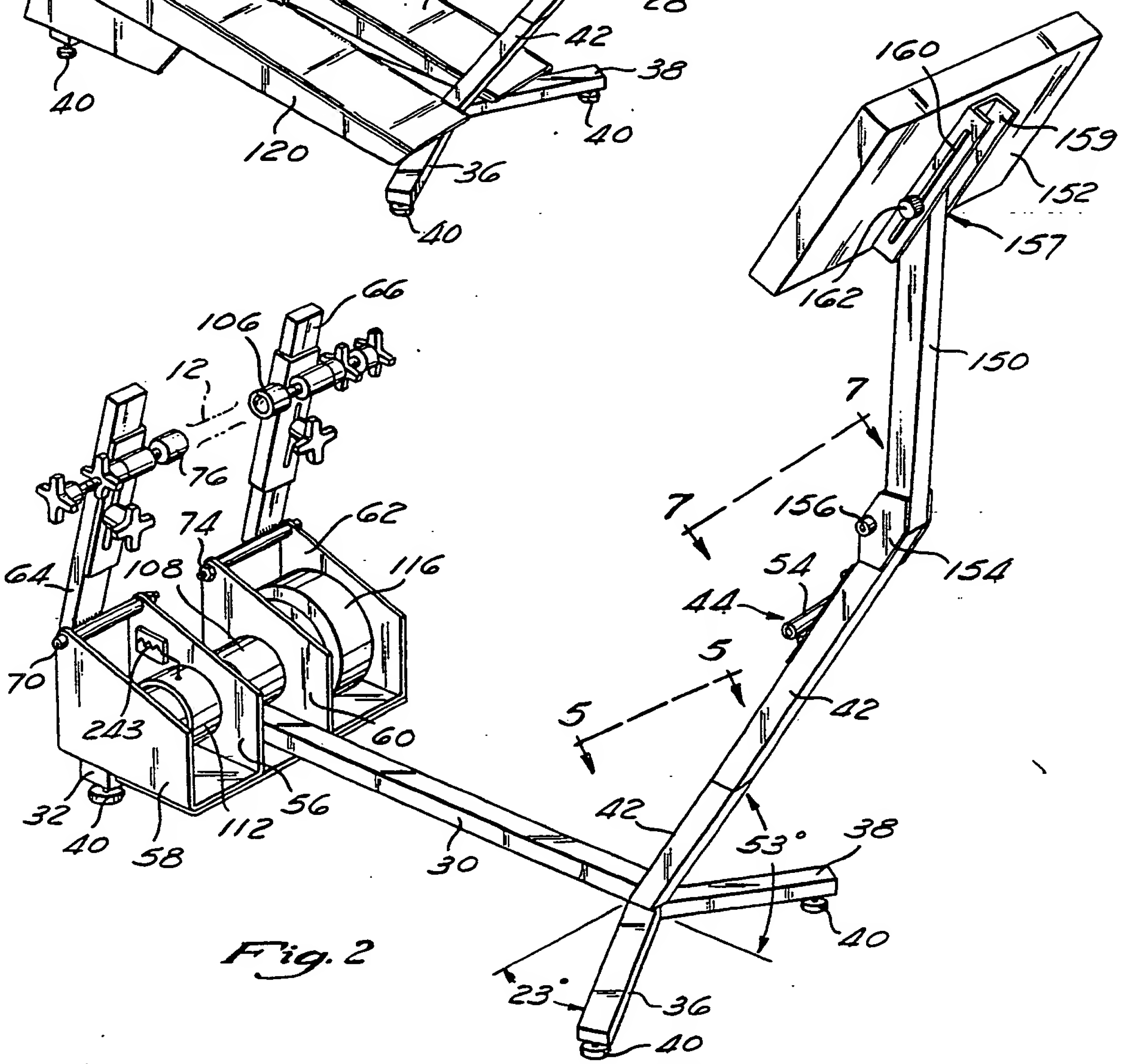
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23°
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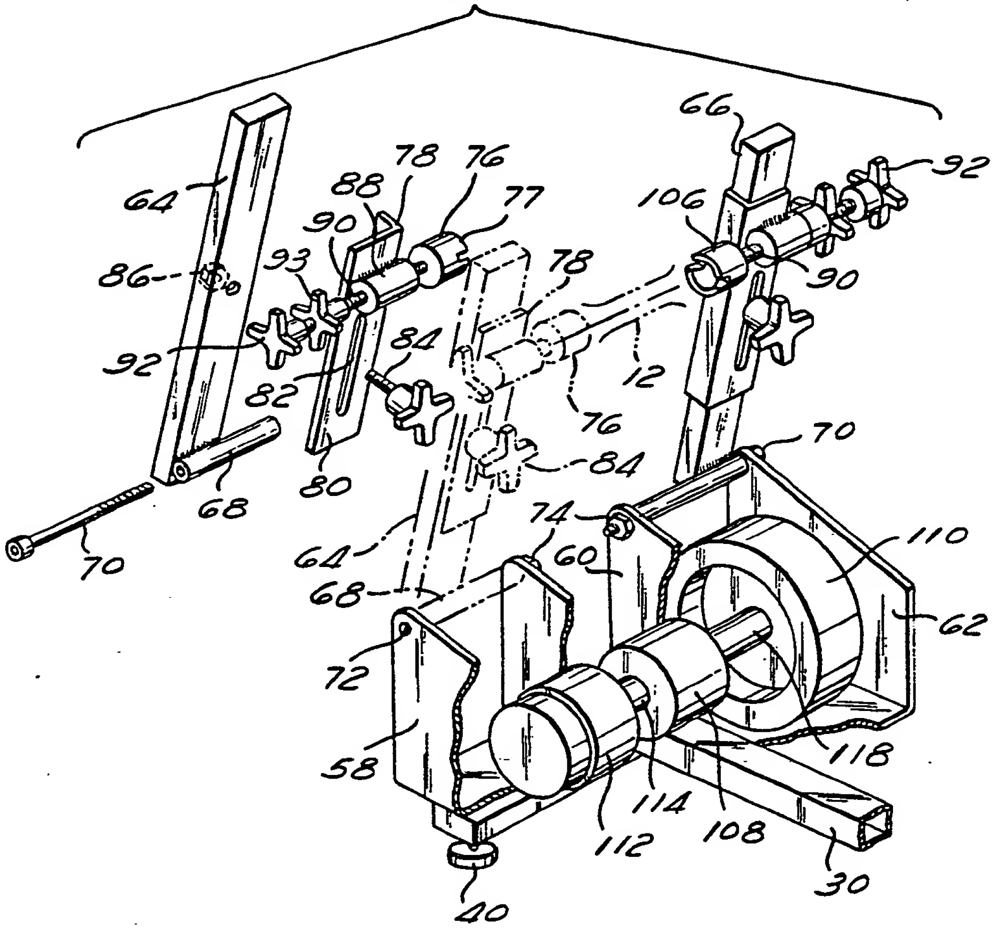
Fig. 2

Fig. 3



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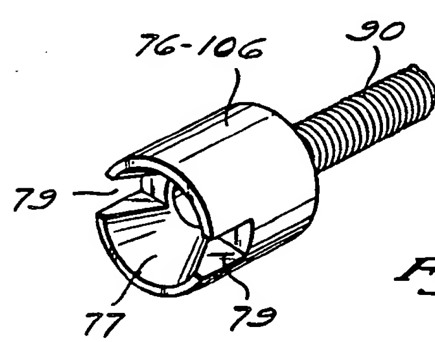

76-106
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79
77
79

Fig. 4

3/9

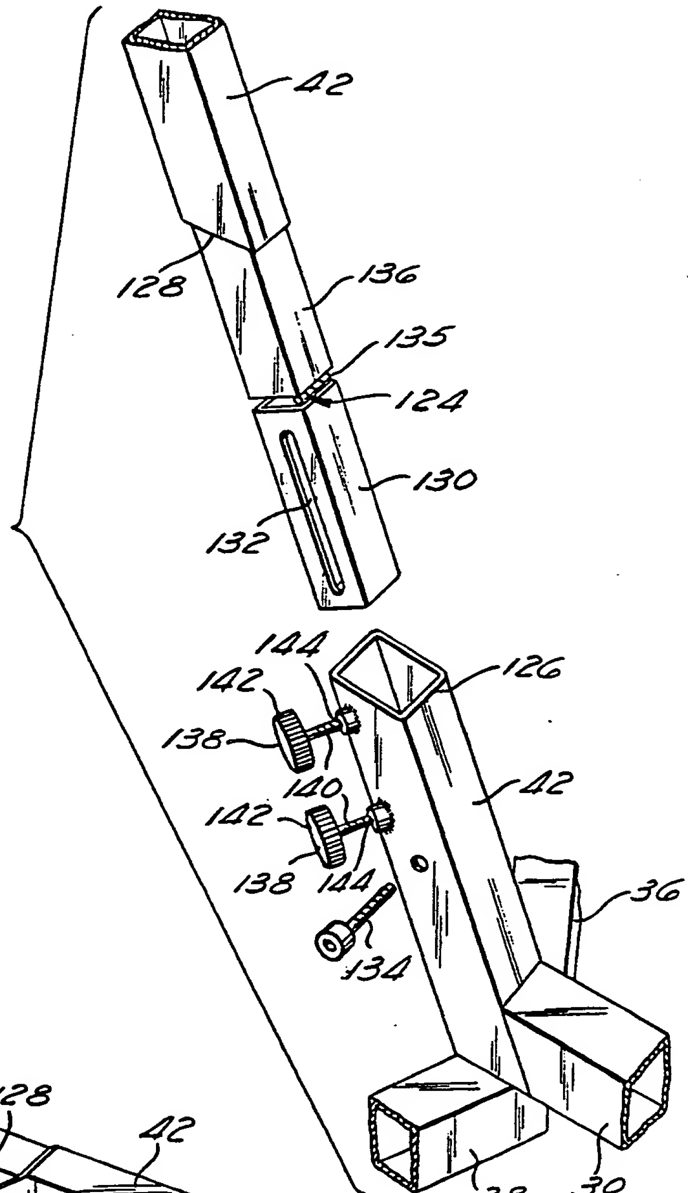
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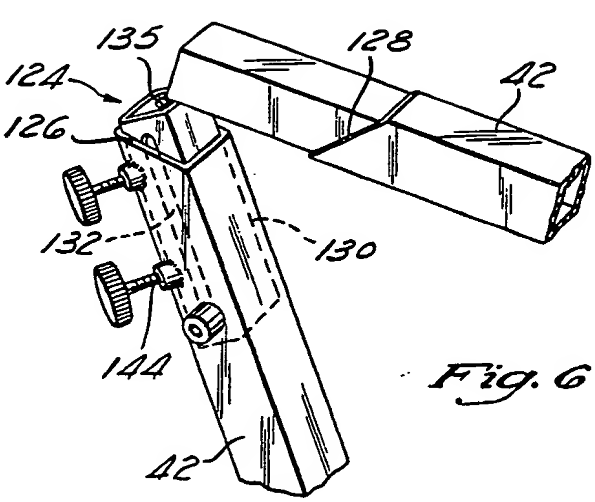
Fig. 5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42

Fig. 6

4/9

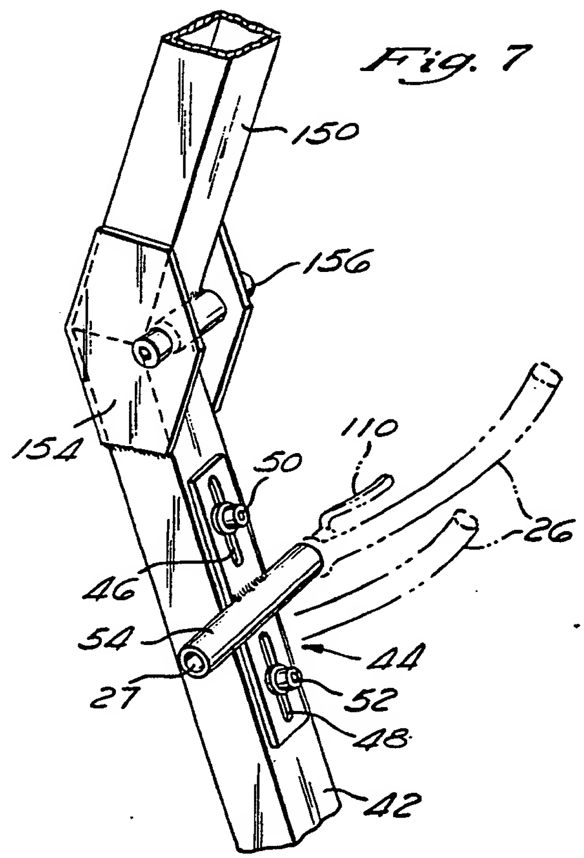


Fig. 7

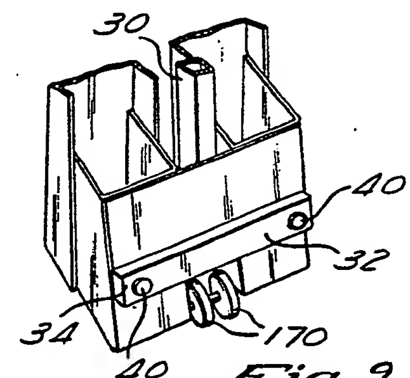


Fig. 9

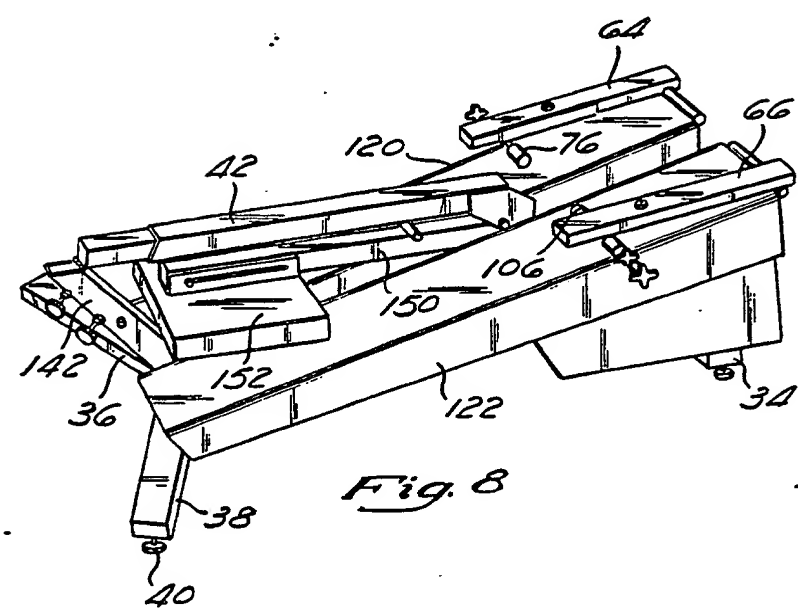


Fig. 8

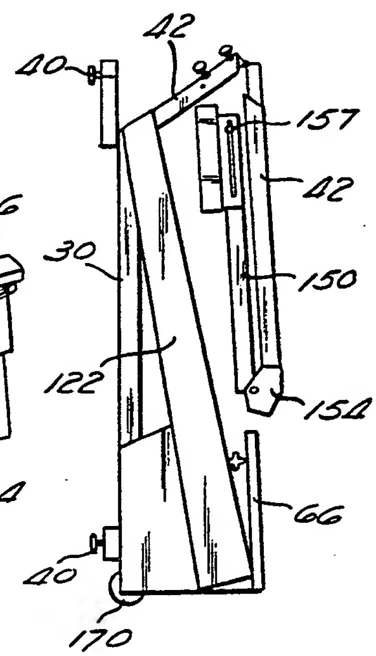


Fig. 10

Fig. 11

TEST 1 - FRICTION TEST

WARM UP — 206

SET DAC TO 0 — 208

INSTRUCT USER TO BEGIN TEST BY RIDING AT 25 M.P.H. — 210

START COASTDOWN TEST — 214

216 — READ SPEED

218 — STORE IN RAM

220 — SPEED = 5 M.P.H. ? — NO (return to READ SPEED) / YES

COMPUTE dv/dt — 222

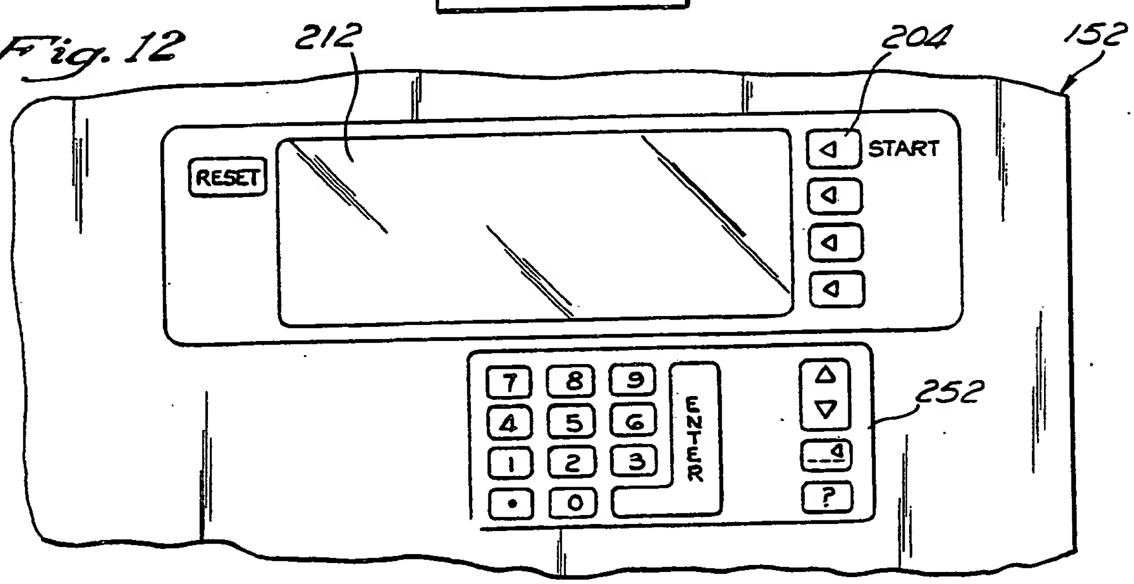
COMPUTE FRICTION FORCE
FRICTION = f (dv/dt) SYSTEM INERTIA — 224

226 — STORE FRICTION VALUES IN RAM (A&B)

227 — COMPUTE POWER TO OVERCOME FRICTION

TO TEST 2 — 228

Fig. 12



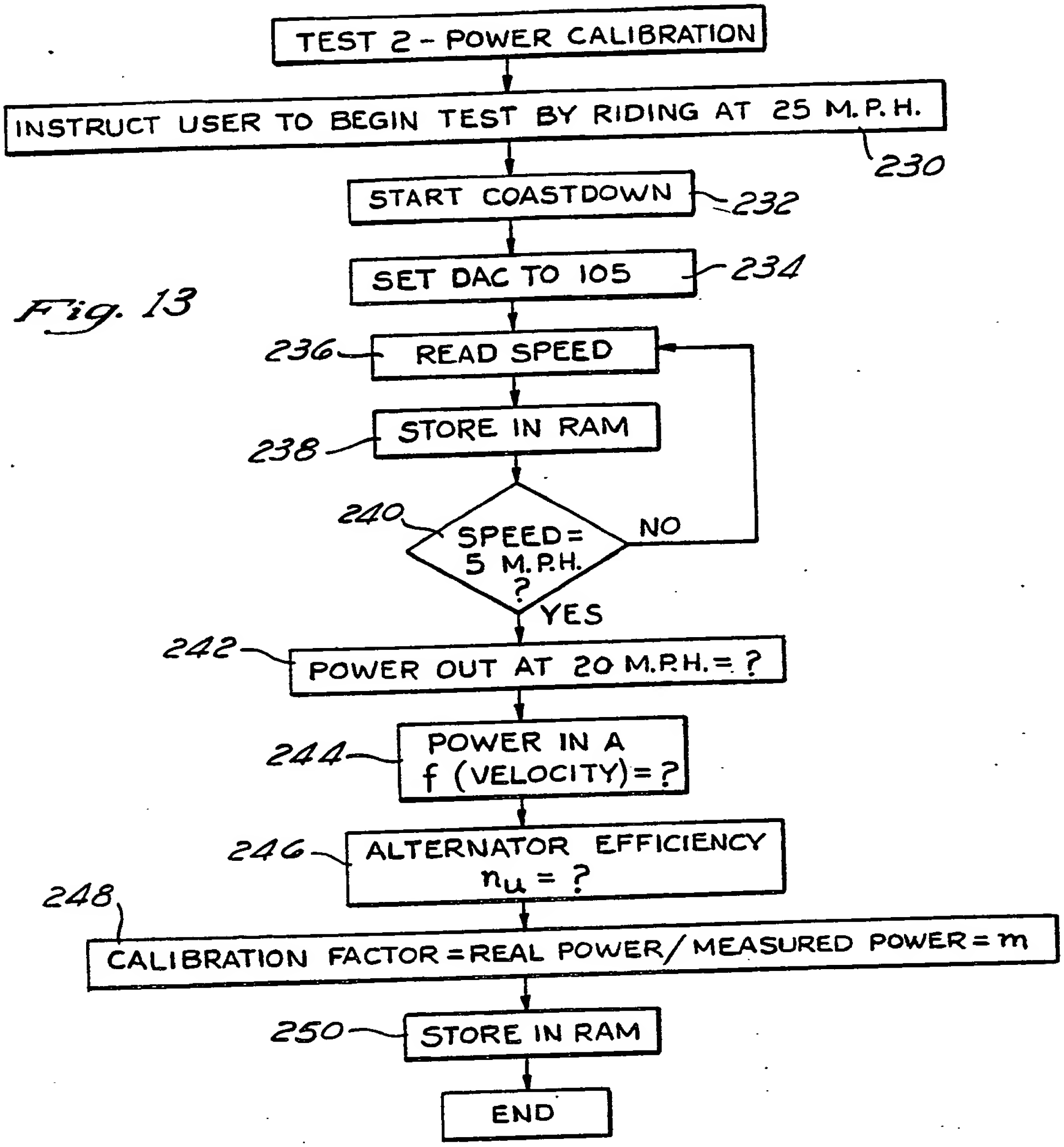

TEST 2 - POWER CALIBRATION
INSTRUCT USER TO BEGIN TEST BY RIDING AT 25 M.P.H.
230
START COASTDOWN
232
SET DAC TO 105
234
236
READ SPEED
238
STORE IN RAM
240
SPEED= 5 M.P.H. ?
NO
YES
242
POWER OUT AT 20 M.P.H.= ?
244
POWER IN A f (VELOCITY)= ?
246
ALTERNATOR EFFICIENCY n_u = ?
248
CALIBRATION FACTOR = REAL POWER/ MEASURED POWER = m
250
STORE IN RAM
END

Fig. 13

Fig. 14

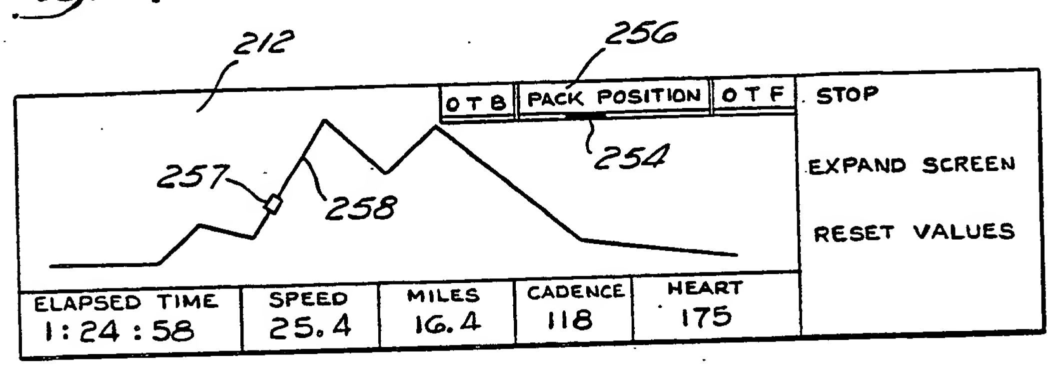
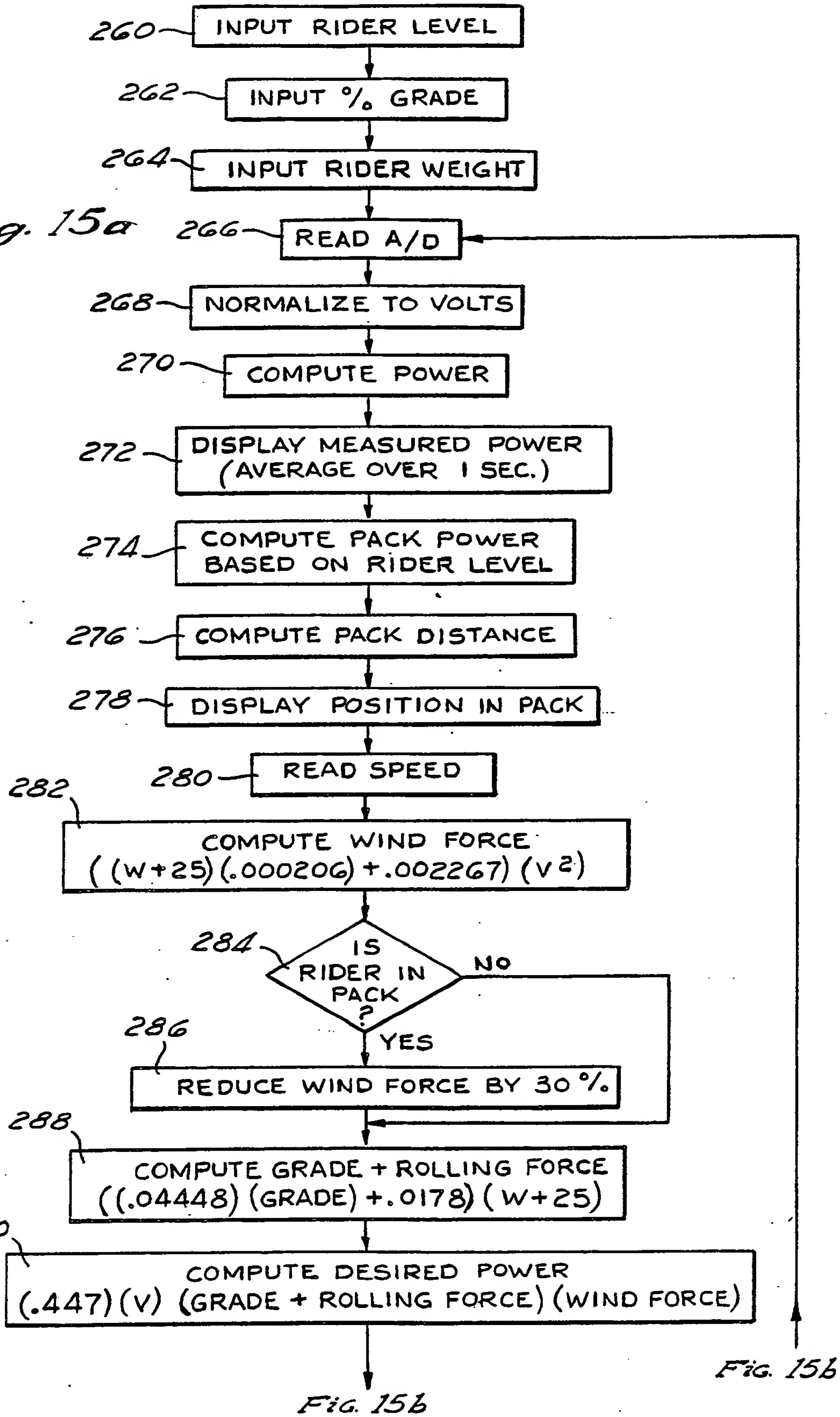

212
256
OTB
PACK POSITION
OTF
STOP
EXPAND SCREEN
RESET VALUES
254
257
258
ELAPSED TIME
1:24:58
SPEED
25.4
MILES
16.4
CADENCE
118
HEART
175

Fig. 15a


260 INPUT RIDER LEVEL
262 INPUT % GRADE
264 INPUT RIDER WEIGHT
266 READ A/D
268 NORMALIZE TO VOLTS
270 COMPUTE POWER
272 DISPLAY MEASURED POWER (AVERAGE OVER 1 SEC.)
274 COMPUTE PACK POWER BASED ON RIDER LEVEL
276 COMPUTE PACK DISTANCE
278 DISPLAY POSITION IN PACK
280 READ SPEED
282 COMPUTE WIND FORCE ((W+25)(.000206)+.002267)(V2)
284 IS RIDER IN PACK ?
NO
YES
286 REDUCE WIND FORCE BY 30%
288 COMPUTE GRADE + ROLLING FORCE ((.04448)(GRADE)+.0178)(W+25)
290 COMPUTE DESIRED POWER (.447)(V) (GRADE + ROLLING FORCE)(WIND FORCE)
FIG. 15b
FIG. 15b

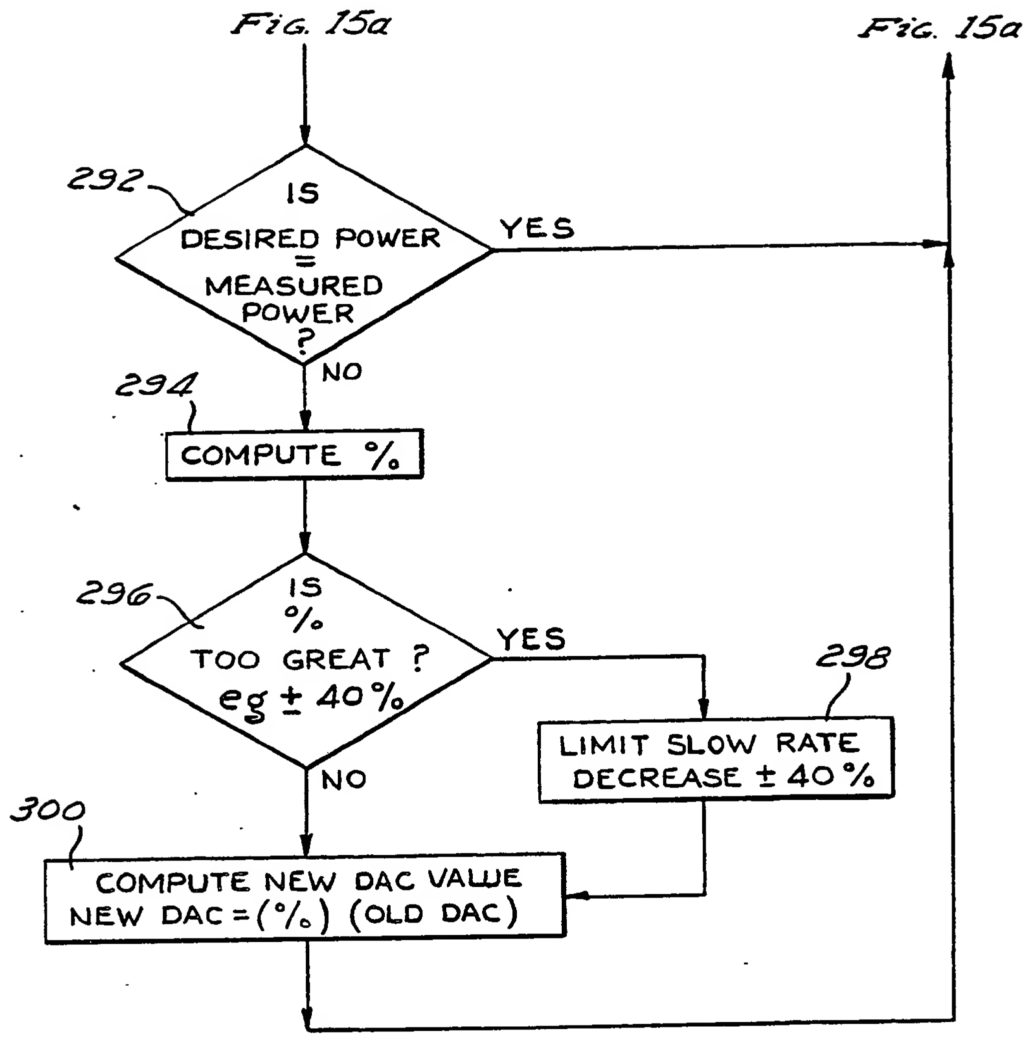


Fig. 15a
Fig. 15a
292
IS DESIRED POWER = MEASURED POWER ?
YES
NO
294
COMPUTE %
296
IS % TOO GREAT ? eg ± 40%
YES
298
LIMIT SLOW RATE DECREASE ± 40 %
NO
300
COMPUTE NEW DAC VALUE
NEW DAC = (%) (OLD DAC)

Fig. 15b

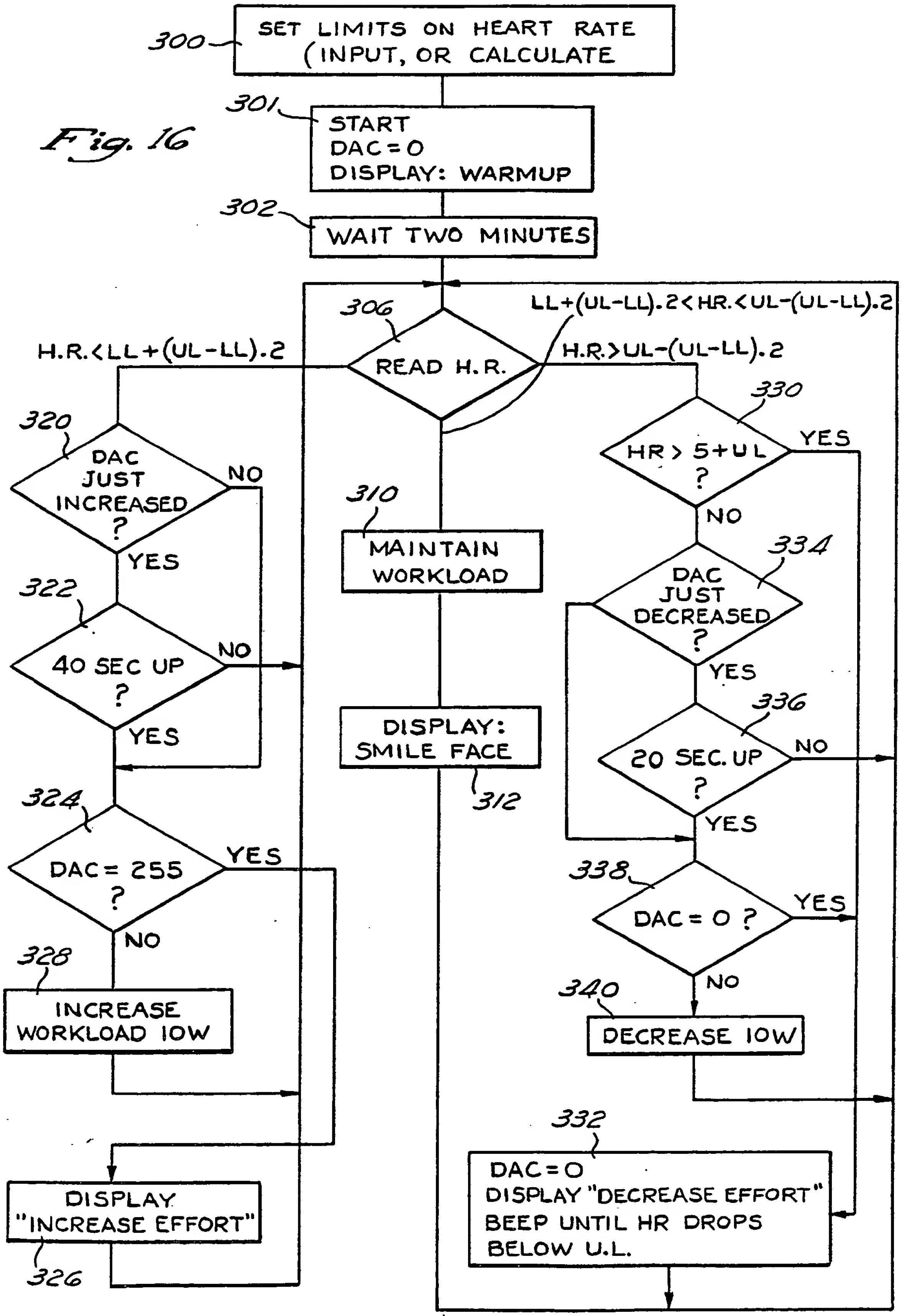

SET LIMITS ON HEART RATE (INPUT, OR CALCULATE
300
START
DAC=0
DISPLAY: WARMUP
301
WAIT TWO MINUTES
302
READ H.R.
306
LL+(UL-LL).2<HR.<UL-(UL-LL).2
H.R.<LL+(UL-LL).2
H.R.>UL-(UL-LL).2
DAC JUST INCREASED ?
320
NO
YES
40 SEC UP ?
322
NO
YES
DAC= 255 ?
324
YES
NO
INCREASE WORKLOAD 10W
328
DISPLAY "INCREASE EFFORT"
326
MAINTAIN WORKLOAD
310
DISPLAY: SMILE FACE
312
HR > 5+UL ?
330
YES
NO
DAC JUST DECREASED ?
334
YES
20 SEC. UP ?
336
NO
YES
DAC = 0 ?
338
YES
NO
DECREASE 10W
340
DAC=0
DISPLAY "DECREASE EFFORT"
BEEP UNTIL HR DROPS BELOW U.L.
332

Fig. 16

INTERNATIONAL SEARCH REPORT

International Application No. PCT/US88/02905

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) 6

According to International Patent Classification (IPC) or to both National Classification and IPC

IPC (4) : A63B 21/00 21/24
US. CL : 272/73,129,dig. 6

II. FIELDS SEARCHED

Minimum Documentation Searched 7

Classification System	Classification Symbols
U.S.	272/73,129, Dig. 5, Dig. 6 73/379 128/706

Documentation Searched other than Minimum Documentation to the Extent that such Documents are Included in the Fields Searched 8

III. DOCUMENTS CONSIDERED TO BE RELEVANT 9

Category *	Citation of Document, 11 with indication, where appropriate, of the relevant passages 12	Relevant to Claim No. 13
Y	GB,A, 0,017,570, (THOMPSON), 15 August 1898, shows roller g, resistance r, pivot e, front and rear supports d. See page 1 lines 15-21; page 2 lines 19-25.	12-20
Y	DE,A, 2,950,605, (KEIPER), 19 June 1981, shows pivotal rear axle supports 17 (Fig 1) and variable load means (Fig 5).	12-20
Y	US,A, 3,845,756, (OLSSON), 05 Nov. 1974, shows control means which monitors person's heart rate and adjusts the load. See col. 1 lines 15-20; col. 2 lines 17-24.	21-22
A	US,A, 4,441,705, (BROWN), 10 April 1984, shows front fork support 14, rear wheel load means 22. See column 4, lines 13-20.	12-20

* Special categories of cited documents: 10

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

IV. CERTIFICATION

Date of the Actual Completion of the International Search	Date of Mailing of this International Search Report
21 October 1988	11 JAN 1989
International Searching Authority	**Signature of Authorized Officer**
ISA/US	S. R. Crow S.R. Crow